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UNEP/IOC Guidelines on Survey and Monitoring of Marine Litter

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GPA

UNEP/IOC Guidelines on Survey and Monitoring of Marine Litter

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IOC Technical Series No. 83

by

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with

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Foreword

Marine litter is found in all sea areas of the world – not only in densely populated regions, but also in remote places far away from any obvious sources. Marine litter originates from many sea-based and land-based sources and causes a wide spectrum of environmental, economic, safety, health and cultural impacts. The very slow rate of degradation of most marine litter items, mainly plastics, together with the continuously growing quantity of the litter and debris disposed, is leading to a gradual, but dramatic increase in the quantities of marine litter in our oceans and world shores.

In response to the global challenge posed by marine litter, UNEP's Regional Seas Programme (RSP) and the Global Programme of Action (GPA) embarked in 2003 on the development of a ***'Global Initiative on Marine Litter'***. Although marine litter is found in all oceans and sea areas of the world, this initiative focuses on the establishment and development of pilot regional activities in twelve regions (Baltic Sea, Black Sea, Caspian Sea, East Asian Seas, Eastern Africa, Mediterranean Sea, Northeast Atlantic, Northwest Pacific, Red Sea and Gulf of Aden, South Asian Seas, South East Pacific, and Wider Caribbean) that are particularly affected. The global initiative also provides a global platform for the establishment of partnerships, cooperation and coordination of activities for the control and sustainable management of marine litter. Most of these activities have been developed by UNEP/RSP in close cooperation with the secretariats of participating Regional Seas Conventions and Action Plans and in consultation and, when appropriate, in cooperation with UN Agencies, including IOC of UNESCO, FAO and IMO.

The problem of marine litter was recognized by the U.N General Assembly (UNGA), which in its Resolution A/60/L.22 (Nov. 2005) calls for national, regional and global actions to address the problem of marine litter. This resolution notes the lack of information and data on marine debris, encourages States to develop partnerships with industry and civil society, urges States to integrate the issue of marine debris within national strategies dealing with waste management; encourages the development of appropriate economic incentives to address this issue, and encourages states to cooperate regionally and subregionally to develop and implement joint prevention and recovery programmes for marine debris. A number of regions and countries have taken some steps to address the marine litter issue but despite all these efforts there are indications that the marine litter problem keeps growing.

As recognized in the UNGA Resolution one of the significant barriers to addressing marine litter is the absence of adequate science-based monitoring and assessment programmes that will provide useful information, from which the most critical impacts of litter, on national, regional and global scales can be determined. Changes in accumulation rates and composition, trends over time and the effectiveness of management systems are also hard to assess without good monitoring methodologies. Although monitoring of marine litter is currently carried out within a number of countries around the world, the methods of survey and monitoring used tend to be very different, preventing comparisons and harmonization of data across regions or time-scales.

In order to confront this problem the Regional Seas Programme of UNEP launched, in full cooperation with the Intergovernmental Oceanographic Commission (IOC) of UNESCO, the development of the ***UNEP/IOC Guidelines on Survey and Monitoring of Marine Litter*** that will assist policy makers and support efforts by regions, countries, Regional Seas Programmes and other relevant organizations to address the problem of monitoring and assessment of marine litter.

These Guidelines include a comparative analysis of information from around the world on existing experience and methods for surveys, monitoring, reporting protocols and assessment of marine litter. The compilation of the information and the development of the Guidelines were carried out by a group of experts from all around the world and representing all oceans, lead by Prof. Anthony Cheshire of Australia and supported by the Government of Australia. UNEP and IOC wish to thank all the scientists and individuals who took part in this project!

It is a hope by all organizations and individuals involved in the preparation of these Guidelines that they will be adopted and implemented for years to come by the relevant international and national organizations, regions and countries.

Dr. Ellik Adler
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UNESCO/IOC, Paris

Acknowledgments

I would like to acknowledge the substantial efforts by the many people who contributed to the development of these guidelines. Although some of you are listed as co-authors it is important that your contributions should not be understated so the following is intended as a thankyou to the many people who helped in this project.

I would like to make special mention of the work by Ellik Adler whose vision, drive and enthusiasm took the project from inception to completion. Ellik has led the way, working tirelessly to illuminate the issues and challenges we all face in dealing with the problems of marine litter.

Each and every one of my co-authors provided invaluable help and assistance in locating source material, reviewing ideas and concepts and providing the advice, feedback and critical review that were essential to developing this document. Whereas each of you came with a different background and bought different experiences to the table your willingness to work collectively was central to us reaching a consensus on some very challenging issues.

The contributions by Ljubomir Jeftic, Seba Sheavly, Yuval Cohen and Alexander Tkalin were also greatly appreciated for the help they provided in developing the initial framework for the project and also for their tireless contributions editing and reviewing the final document. Grant Westphalen is also thanked for his ongoing support and assistance and particularly for his support in developing the first complete draft of the document.

No project can be completed without the support of the people who make things happen behind the scenes. This project benefited enormously from the work of Julian Barbiere and his team at the IOC who worked with UNEP to manage and administer the project, the UNEP team including Peter Manyara provided ongoing logistic and technical support and our workshop in Thailand was a success largely due to the hard work and planning from Srisuda Jarayabhand and her team. To all of these people a warm thankyou for your help and assistance.

Ilse Kiessling (representing the Government of Australia) was prominent in contributing her knowledge, ideas and not least - access to her library - which helped to get the project off the ground and through to completion.

To all of you – it was a great pleasure working with you and I sincerely hope that our efforts will make a difference in helping the world to address the complex and challenging problems of marine litter.

Anthony Cheshire

March 2009

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Glossary and Acronyms

Term	Definition
AMDS	Australian Marine Debris Survey
AMSA	Australian Maritime Safety Authority
ANZECC	Australian and New Zealand Environment and Conservation Council
Beach cast	Material that has been deposited on beaches after being washed up by storm or tidal movement.
Benthic	On the sea-bed – benthic litter is litter found sitting on or entangled with objects on the seabed.
CEARAC	Coastal Environment Assessment Regional Activity Centre
CCI	Clean Coast Index
CMC	Centre for Marine Conservation (now the Ocean Conservancy)
Debris	See Litter – although the words “litter” and “debris” are sometimes used to indicate “rubbish” with different sources in this document the two words are taken to be inter-changeable. Note also that the UN resolution A/60/L.22 and supporting documents used the term “debris” but subsequent UN programmes and documentation have used the term “litter”.
DEW	Australian Government Department of the Environment and Water Resources
Flux rate	Flux rate is the amount of litter that accumulates on a given length of beach over a given period of time expressed as [unit quantity of litter] per [unit length of beach] per [unit time]). See also standing crop.
GESAMP	Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
HELCOM	Governing body of the "Convention on the Protection of the Marine Environment of the Baltic Sea Area" – more usually known as the Helsinki Convention.
ICC	International Coastal Cleanup
IMCRA	Interim Marine and Coastal Regionalization for Australia
IMO	International Maritime Organization
IOC of UNESCO	Intergovernmental Oceanographic Commission of United Nations Educational, Scientific and Cultural Organization
Large Marine Ecosystem	Large marine ecosystems (LMEs) represent large, continuous ocean areas (typically around 200,000 km^2) that have relatively distinct hydrography and bathymetry. LME’s typically encompass coastal bays and estuaries and extend out to the edge of the adjacent continental shelf. Importantly they represent areas with a high degree of physical, biological and ecological connectivity with constituent trophically dependent populations. The system of LMEs has been developed by the US National Oceanic and Atmospheric Administration (NOAA) to assist in the identification and characterization of areas of ocean for conservation purposes.

Term	Definition
Litter Characterization	System used to classify different types of litter. Many different systems have been used in the literature including grouping litter based on its material composition (e.g. plastic vs wood vs metal), form (e.g. bottles vs crates vs sheets) or source (e.g. recreational activities vs fishing vs commercial transport). In this report a comprehensive litter characterization scheme has been developed that uses both material composition and form.
Litter Monitoring	Repeated surveys of beaches, sea bed and/or surface waters to determine litter quantities such that information can be compared with baseline data to see if changes occur through time and / or in response to management arrangements.
Litter Survey	Structured set of procedures to provide a quantitative assessment of the amount of litter in a given location.
LME	See Large Marine Ecosystem
MAP	Mediterranean Action Plan - Action Plan for the Protection of the Marine Environment and the Sustainable Development of the Coastal Areas of the Mediterranean
Marine Litter	Waste, discarded or lost material resulting from human activities – marine litter is any such material that has made it into the marine environment, including material found on beaches or material that is floating or has sunk at sea. In some countries organic material (e.g. faeces or food waste) are included as litter. In this document organic waste has not been included and we only consider manufactured materials (including processed timber). Materials of natural origin, including seagrass or algal wrack and other vegetation, are explicitly excluded.
MARPOL	International Convention for the Prevention of Pollution from Ships
MERRAC	Marine Environment Emergency Preparedness and Response Regional Activity Centre
NDNHI	The Northwest Hawaiian Island marine litter survey
NMDMP	National Marine Debris Monitoring Program developed by the Ocean Conservancy in the USA
NOWPAP	Northwest Pacific Action Plan - adopted in 1994 by the four Member States, namely the People's Republic of China, Japan, the Republic of Korea and the Russian Federation as a part of the UNEP Regional Seas Programme (see RSP).
NRETA	Natural Resources, Environment and the Arts, Northern Territory, Australia
OSPAR	The 1992 OSPAR Convention is the current instrument guiding international cooperation on the protection of the marine environment of the North-East Atlantic. It combined and up-dated the 1972 Oslo Convention on dumping waste at sea and the 1974 Paris Convention on land-based sources of marine pollution.
RCU	Regional Coordinating Unit for any of the various UNEP Regional Seas Programmes (see RSP).
RSP	The UNEP Regional Seas Programme
Standing crop	Standing crop is a measure of the amount of litter on the beach expressed as the [unit quantity of litter] per [unit length of beach]). See also Flux rate.

Term	Definition
Trawl shot	The term trawl shot is used to denote a single trawling event where the net (or grapple) is deployed behind the boat, dragged (or trawled) through the water and then recovered. Each trawl shot can therefore be taken as a sample (or sub-sample) of an area.
Trawling	Use of a net that is dragged through some portion of the water column or along the sea floor.
TWG	Technical Working Group – refers to the group responsible for compiling this report see Appendix A.
UNEP	United Nations Environment Programme
UNEP Regional Seas Programme	The Regional Seas Programme was launched in 1974 in the wake of the 1972 United Nations Conference on the Human Environment held in Stockholm, Sweden. Currently, eighteen regions are covered by the Regional Seas family. Thirteen regional seas programmes have been established under the auspices of UNEP. The East Asia (COBSEA), Eastern Africa (Nairobi Convention), Mediterranean (Barcelona Convention), Northwest Pacific (NOWPAP), West and Central Africa (Abidjan Convention) and Wider Caribbean (Cartagena Convention) programmes are directly administered by UNEP. The Black Sea (Bucharest Convention), Northeast Pacific (Antigua Convention), Red Sea and Gulf of Aden (Jeddah Convention), ROPME Sea Area (Kuwait Convention region), South Asian Seas (SAS, SACEP), Southeast Pacific (CPPS, Lima Convention) and South Pacific (SPREP, Noumea Convention) programmes are independently administered by their regional secretariats. Furthermore, five regional partner programmes are in place in the Antarctic (CCMLAR), the Arctic (PAME), the Baltic Sea (Helsinki Convention, HELCOM), the Caspian (Teheran Convention) and Northeast Atlantic (Oslo Paris Convention, OSPAR). The RSP aims to address the accelerating degradation of the world's oceans and coastal areas through the sustainable management and use of the marine and coastal environments, by engaging neighbouring countries in comprehensive and specific actions to protect their shared marine environment. In total more than 140 countries participate in regional programmes thus the RSP is one of the most globally comprehensive initiatives for the protection of marine and coastal environments.
UNESCO	United Nations Educational, Scientific and Cultural Organization
Visual survey	A litter survey conducted by visual assessment rather than by physical collection of litter items. Typically visual surveys are used when litter items can be seen (observed) but not collected, for example, when using underwater cameras or when observing from planes or ships travelling at sea.
WWF	World Wide Fund for Nature

Executive Overview

Background to the development of operational guidelines

Globally our awareness of both the pervasiveness and magnitude of marine litter and the associated environmental and social problems is growing (Ribic et al. 1992, ANZECC 1996a, GESAMP 2001, Kiessling 2003, Cho 2005, UNEP 2005, OSPAR 2006, HELCOM 2007). This growth in knowledge is being paralleled by a concomitant increase in the number and scope of national and international marine litter investigations and assessment programmes. The objectives underpinning these litter assessment programmes are quite diverse with groups/organizations variously targeting increased public awareness, better understanding of the risks and impacts of litter, more understanding of litter sources and sinks to support improved management and not the least, cleaner waterways and beaches at local, regional, national and international scales. This variety in the purpose of assessment programmes is matched by the diversity in the operational structure of those programmes.

Regardless of the underpinning motivation, marine litter investigations will generally fall into one of three basic types:

1) Beach litter surveys.
2) Benthic litter surveys, which include:
    a) Observations made by divers, submersibles or camera tows.
    b) Collection of litter via benthic trawls.
3) Floating litter surveys, which include:
    a) Observations made from ship or aerial based platforms.
    b) Collection of litter via surface trawls.

Ultimately, to effectively manage and thereby mitigate the impacts from marine litter, there is a need to develop a good understanding of the problems and specifically to increase our knowledge about the principle types and sources of litter and the behaviours that result in litter entering the marine environment. To achieve this aim, there is a need to ensure that good quality data are available that will allow comprehensive analyses of the nature and sources of litter in marine environments and how these vary through time and in response to management interventions.

In spite of growing interest and a mounting body of evidence from research and surveys, it is widely accepted that a major factor that limits our knowledge of (and therefore the ability to manage) marine litter results from inconsistencies in the design and delivery of sampling and assessment programmes. These inconsistencies largely result from a lack of consistent objectives and litter classification systems between alternative monitoring programmes (Ribic et al. 1992, ANZECC 1996a, Cheshire and Westphalen 2007).

There is a growing need to develop standardized operational guidelines for marine litter survey and monitoring programmes so that litter levels on our beaches and within our seas and oceans can be estimated and interpreted through long-term, broad scale comparative studies that will support management at both national and international scales. Similarly, given that marine litter management ultimately relates to social and behavioural changes, there is a need to develop or maintain public awareness and education through simpler, less rigidly structured, programmes.

Objectives

The objectives for this study were to develop a set of standardized operational guidelines for the conduct of beach, benthic and floating litter assessments. In working to achieve this outcome it became clear that there was also a need to address the different underlying purposes, particularly in relation to beach litter assessments, and to that end we have developed two classes of surveys:

1) Comprehensive surveys for beach, benthic and floating marine litter

    These protocols are targeted at the collection of highly resolved data to support the development and/or evaluation of mitigation strategies in coastal and marine systems. The protocol for these surveys includes a highly structured framework for observations at regional, national and international scales.

2) Rapid surveys for beach litter

   This protocol comprises a simplified version of the comprehensive beach survey, targeted primarily at developing public awareness and education about marine litter issues and is thus not constrained by the need to fit within a broader spatio-temporal comparison framework. Such surveys may be used as a vehicle for broader based community engagement and in building community capacity when working towards inclusion within the comprehensive survey framework.

In developing the guidelines marine litter was defined as any waste, discarded or lost material, resulting from human activities, that has made it into the marine environment, including material found on beaches or material that is floating or has sunk at sea. Some organic materials (e.g. faeces or food waste) have been explicitly excluded and we do not include naturally sourced materials such as vegetation (e.g. seagrass wrack, algae or river sourced trees and branches). Organic materials have only been included where they have been through some form of processing (e.g. cloth and processed timber).

Scope of this report

As noted by the United Nations General Assembly Resolution (A/60L.22), one of the most significant barriers to addressing the global problem of marine litter is the absence of information that can be used to determine the sources, the movement and paths, the oceanographic dynamics, the trend and the more general status of marine litter. This kind of information is basic and mandatory in order to assess the impact of marine litter on national, regional and global scales. The absence of harmonized and globally agreed upon scientific methodologies to monitor changes in accumulation rates and the composition of litter, and the effectiveness of management arrangements over time are critical issues that require the development of appropriate guidelines.

In order to address this problem the Regional Seas Programme (RSP) of UNEP, together with the IOC of UNESCO, and with the support of the Government of Australia, within the context of the *'Global initiative on marine litter'* initiated the work on developing guidelines for the 'standardization' and harmonization of the survey and monitoring of marine litter worldwide. Such guidelines will contribute to the global efforts, especially of developing countries, to address and abate marine litter and will assist scientists, governmental authorities and policy makers and respective efforts by governments, NGOs, Regional Seas Programmes and other relevant organizations to address the problem of the monitoring and assessment of marine litter.

Within the framework of the collaboration between IOC and UNEP, related to the development of the 'UNEP/IOC Guidelines on Survey and Monitoring of Marine Litter', this report aims to outline practical operational guidelines for the survey and monitoring of marine litter and in particular:

1) To collect information from around the world on existing experience and methods for the monitoring and assessment of marine litter drawing on information already compiled by UNEP, OSPAR, HELCOM, the Australian Department of the Environment and Water Resources, the Ocean Conservancy's NMDMP and other relevant sources.
2) To develop a comparative analysis of selected methodologies for marine litter survey and monitoring, including reporting protocols and forms.
3) To develop a set of practical operational guidelines on survey and monitoring of on-shore, floating and sea-floor marine litter for consistent application worldwide. These guidelines include advice on the format and organization of data needed to support statistical and trend based analyses.

The survey design, guidance and data recording protocols are intended to support comprehensive surveys and monitoring as well as rapid surveys suitable for application by community-based or other non-research trained personnel.

Given the extensive logistical requirements for surveys of floating and benthic litter, it is not practical to develop rapid assessment surveys for either floating or benthic litter. It is recognized however, that community groups may well participate in *ad-hoc* clean-up and removal operations for floating or benthic litter which may then be reported in general terms (e.g. total volume or weight of material collected).

Similarly, while there is broad agreement about the importance of microplastics (a component of neustonic litter) as a threat to wildlife (Derraik 2002, Lattin et al. 2004), investigations into this type of litter are technically demanding and require specialist equipment and training (see Lattin et al. 2004); specific survey guidelines for this form of litter have not been included.

Approach used in developing guidelines

In order to organize the preparation of the Guidelines, the RSP of UNEP and the IOC of UNESCO, with the support of the Government of Australia, established an international Technical Working Group (TWG) comprising of sixteen "globally spread" experts from various regions and countries of the world. The TWG began work in July 2007 with support from UNEP and IOC; Prof. Anthony Cheshire from Australia took the lead role in the project and acted as a Chief Scientist, Team Leader and Coordinator of the TWG.

The TWG undertook a detailed review of 13 different sampling protocols that are currently being used around the world to survey beach cast, benthic and/or floating marine litter. Survey protocols were assessed against 46 criteria related to the basic structure of the survey, the analysis of sampling units, the frequency and timing of surveys, the systems used for litter classification and the underpinning framework for facilitation and management of logistics.

Results of this review were summarised and then used to determine the best way to structure different types of litter surveys. The outcomes from this work have been incorporated into the development of these Operational Guidelines. In framing these recommendations a set of draft guidelines were reviewed by all members of the TWG and these were further developed during a workshop held in Phuket, Thailand during May 2008. Following this workshop the results were compiled into an agreed set of operational guidelines to support the delivery of marine litter surveys.

In total four sets of guidelines have been developed, one for each of:

1) Comprehensive assessments of beach cast litter;
2) Assessments of benthic litter;
3) Assessments of floating litter; and
4) Rapid assessments of beach cast litter.

Chapter I presents an introduction to marine litter and the associated problems. General information about the application of these guidelines in a global / regional framework is detailed in Chapter II while the detailed methodology for each of the guidelines is presented in Chapters III-VI. Appendix A lists the TWG membership while Appendix B provides a summary of the findings from the review of the various litter assessment programmes that formed the background to these guidelines.

Chapter I. Introduction to marine litter

Despite international, national and local prohibitions (e.g. ANZECC 1996a, GESAMP 2001, Kiessling 2003, NRC 2008), the level of manufactured litter lost or deliberately discarded into the world's seas and oceans is substantial and represents a growing threat to marine environments and industries (e.g. ANZECC 1996a, b, Barnes 2002, Kiessling 2003). Marine litter accumulates on virtually all coasts from the poles to the equator (e.g. Haynes 1997, Convey *et al.* 2002) and at least some form of litter can be found on almost any beach anywhere in the world, irrespective of its remoteness from domestic sources. Litter may originate from many sources including (e.g. Jones 1995, ANZECC 1996a, Kiessling 2003, NOWPAP 2007a, Otley and Ingham 2003):

- commercial and recreational fisheries and aquaculture operations
- vessels – including cargo, bulk carrier, military, surveillance, research, passenger ships and non-commercial pleasure craft
- stormwater and urban run off
- wind blown from land
- riverine inputs
- beach users, including deliberate illegal dumping
- offshore oil rigs

The International Convention for the Prevention of Pollution from Ships (*MARPOL 73/78*) is a major international treaty on marine litter and pollution control for which Annex V relates to garbage. Across the world, various countries enact this treaty through legislative arrangements (e.g. in Australia through the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*). It needs to be understood however that, although MARPOL provides some control over litter from shipping, it does not prohibit discharge of all material from vessels. Furthermore, other sources of litter (e.g. lost fishing gear or land based sources such as domestic discards) represent a substantial, and in some parts of the world an even greater, source of litter into marine and coastal environments.

Other international and regional legal instruments have been developed to cover some of these other litter sources including the London Dumping Convention[1] which addresses dumping at sea and the Barcelona Convention which addresses marine litter from land-based sources.

Nevertheless, irrespective of the legislative framework, prosecutions for illegal disposal of marine litter are rare (e.g. Rees and Pond 1995, Derraik 2002) because the tracing of litter to the source is often difficult or impossible (ANZECC 1996a, Kiessling 2003).

Marine litter – the problem

For the purposes of the guidelines developed herein, the definition of marine litter[2] includes any manufactured or solid waste entering the marine environment irrespective of the source (see Coe and Rogers 1997). Marine litter can thus be categorised into several diverse classes of material (e.g. Ribic *et al.* 1992, ANZECC 1996a, Kiessling 2003, Otley and Ingham 2003, Edyvane *et al.* 2004), including:

- plastics (e.g. moulded, soft, foam, nets, ropes, buoys, monofilament line and other fisheries related equipment, smoking related items such as cigarette butts or lighters)
- metal (e.g. drink cans, bottle caps, pull tabs)
- glass (e.g. buoys, light globes, fluorescent globes, bottles, etc)
- processed timber (including particle board)

[1] The "Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972", was one of the first global conventions to control pollution of the sea through the dumping of wastes and other matter. There are Currently, 85 States are Parties to this Convention. In 1996, the "London Protocol" was agreed to further modernize the Convention and, eventually, replace it. Under the Protocol all dumping is prohibited, except for possibly acceptable wastes on the so-called "reverse list". The Protocol entered into force on 24 March 2006 and there are currently 36 Parties to the Protocol.

[2] Note that the terms "debris" and "litter" are variously used throughout the literature. In some cases they are used to differentiate between marine sourced material (debris) and locally sourced material (litter). In this report the terms are used interchangeably although preference is given to the word "litter".

- paper (including cardboard)
- rubber
- cloth

Furthermore, in some countries organic material (e.g. faeces or food waste) are also included as litter. In these guidelines organic waste has not been included although we do include processed timber. Conversely, materials of natural origin, including seagrass or algal wrack and other vegetation, are explicitly excluded.

The range and scale of impacts from marine litter are diverse (e.g. Dixon and Dixon 1981, Laist 1987, Jones 1995, GESAMP 2001, Moore *et al.* 2001, Barnes 2002, Derraik 2002, Kiessling 2003, Otley and Ingham 2003, UNEP 2005, NRC 2008) and include:

1. Environmental
    a. entanglements and ghost fishing
    b. ingestion (intestinal blockage, malnutrition and poisoning)
    c. blockage of filter feeding mechanisms from small particulate (neustonic) plastic debris
    d. physical damage and smothering of reefs, seagrasses, mangroves
    e. potential to vector marine pests including invasive species.
2. Social
    a. loss of aesthetics and / or visual amenity
    b. loss of indigenous values
    c. antagonism against perceived polluters
    d. perceived or actual risks to health and safety
3. Economic
    a. cost to tourism (loss of visual amenity and obstruction to beach use)
    b. cost to vessel operators (downtime and damage due to entanglements)
    c. losses to fishery and aquaculture operations due to damage or entanglements
    d. costs for clean up, animal rescue operations, recovery and disposal
4. Public Safety
    a. navigational hazards (loss of power or steerage at sea is potentially life threatening)
    b. hazards to swimmers and divers (entanglements)
    c. cuts, abrasion and stick (puncture) injuries
    d. leaching of poisonous chemicals
    e. explosive risk (gas cylinders frequently wash ashore in northern Australia, similarly dumped military ordinance is a problem off the Irish coast)

Litter accumulation in our seas and on our beaches depends upon both the rate at which litter is entering the system and the rate at which it is removed or decays. Estimates for the rate of litter accumulation in the world's seas and oceans vary substantially. The highest estimates suggest accumulation rates as high as 7 billion tonnes per annum (GBRMPA 2006) a figure which may be an over-estimate[3]. Conversely, the lowest estimate of 6.4 million tonnes per annum, although based on a comprehensive assessment, is now quite dated (National Academy of Sciences 1975). Irrespective, it is generally agreed that both the current levels and the rates of input are increasing (e.g. Ryan and Maloney 1993, Barnes 2002, Derraik 2002) in spite of measures targeted at controlling the problem (Williams et al. 2005, National Academy of Sciences 2008). The ever increasing use of plastics that both float and degrade very slowly (Laist 1987) means that litter will remain in the system for protracted periods and over that time it may travel substantial distances (Derraik 2002). Derraik (2002) also suggested that while it is difficult to reliably estimate the amount of plastic entering the marine environment the quantities are substantial.

[3] While estimates vary considerably other sources suggest that plastic production world wide is around 5 kg per annum for every person on earth. Given that plastics typically make up 50%-70% of litter items then as a worst case (assuming all plastic produced ends up in the sea) marine litter production rates would be around 60,000,000 million tonnes. Although the figure of 7 billion tonnes is often reported it is unlikely to be correct and is probably 2-3 orders of magnitude above the real level.

The longevity of many litter components (especially glass and plastics) is widely accepted (e.g. Clarke 1986, Laist 1987, UNEP 1990, UNEP/IOC/FAO 1991, The Ocean Conservancy 2006). A piece of paper the size of a parking ticket might last a month, cigarette butts will last from 1-5 years, a plastic bag for 20-30 years, aluminium cans from 80-500 years but glass and plastic bottles can last much longer (UNEP 1990, The Ocean Conservancy 2006). The Ocean Conservancy International Coastal Cleanup Coordinator Handbook lists 21 different types of litter, obtained from the US National Parks Service, with decomposition times of 2-4 weeks for paper towels up to 1 million years for glass bottles (The Ocean Conservancy 2006). However, these values will vary substantially according to environmental conditions such as sun exposure, particularly UV levels, temperature, oxygen level, wave energy and the presence of abrasive factors (sand, gravel or rock). There is also uncertainty in our understanding of persistence; Clarke (1986) for example, suggests that plastic containers will last around three years, substantially less than the 20-30 years suggested by the US National Parks Service (The Ocean Conservancy 2006). Note that, while fragmentation of litter is not the same as decomposition, this process may enhance the breakdown rate or at the very least change the nature of the risks presented by litter to marine biota or ecosystems.

More research is needed into litter decomposition rates under different environmental conditions so that the half-lives for different litter types can be quantified. Data on half-life will assist in identifying residence times in the oceans and on beaches as well as targeting management strategies at those litter types that are both damaging and persistent (e.g. changing the material composition to preferentially select material that decomposes more rapidly).

Lost and discarded fishing gear is a primary cause for environmental, economic and public safety concern (Jones 1995, Kiessling 2003), but plastics are far and away the most pervasive of marine litter items for which ingestion by marine biota can lead to major health issues and frequently death (Laist 1987, Moore *et al.* 2001, Derraik 2002). Although in general terms netting and monofilament line could be included under plastics, some surveys of marine litter analyse this component separately in order to differentiate these risks (Kiessling 2003, White 2005) and because there is little confusion as to the source. While it is possible that fishing nets may be lost from poorly maintained storage or dumping facilities, derelict nets can generally be attributed to maritime origins. The same cannot be said for other beach litter, particularly items that occur frequently (e.g. smoking related items, plastic bags, bottles, etc), which are generally derived from land based sources (i.e. transport via rivers and drains or via deliberate dumping and discards).

The need to improve marine litter reporting systems

To effectively manage, and thereby mitigate the impacts from marine litter, there is a need to develop a good understanding of the problem and specifically to understand the principle types and sources of litter in the marine environment. To achieve this aim there is a need to ensure that relevant, quality data are available that allow a comprehensive analysis of the nature and sources of litter and how these are changing through time and in response to management interventions.

Beach surveys of accumulated marine litter are the most common means of estimating loads in the sea (e.g. Ribic *et al.* 1992, ANZECC 1996a, b, Rees and Pond 1998, Kiessling 2003, Stuart 2003). However, in spite of growing interest and a mounting body of research, it is widely accepted that a major factor that limits our understanding of (and therefore the ability to manage) marine litter, is the lack of clearly identified objectives and inconsistencies in sampling design and litter classification systems between litter surveys. These inconsistencies are such that they prevent or severely confound the analysis of spatial and temporal patterns (e.g. ANZECC 1996a, b, GESAMP 2001, Kiessling 2003).

Even when sampling methods are similar, comparative studies are often compromised by a lack of information on factors influencing the depositional environment (prevailing winds, local and offshore currents, proximity to land based sources) for the different sampling areas (ANZECC 1996b). In such cases, even when differences in litter loads can be demonstrated between sites it is difficult to interpret these because the sources of the variability remain unknown. The development and evaluation of global strategies for the management of marine litter are thus hampered by an inability to compare and contrast litter levels between different regions.

There is growing need therefore, to develop standardized marine litter sampling guidelines such that litter levels within coastal and marine systems can be estimated and interpreted through long-term, broad scale comparative studies that will support management at both national and international scales (e.g. Wace 1995, ANZECC 1996b, Kiessling 2003, Stuart 2003, Edyvane *et al.* 2004, Cho 2005, HELCOM 2007, NOWPAP 2008, Sheavly 2007).

Lifecycle model for marine litter

A key challenge in developing guidelines for the assessment of marine litter is to identify the major processes that control the entry and / or removal of litter from the oceans and also the transformations that occur during the lifecycle of any given litter item (e.g. when floating litter sinks to become benthic litter or is cast onto a beach to become beach cast litter).

In developing any sampling strategy it is necessary to establish a model of the system being investigated which makes explicit the various assumptions about how the system works. In the following we provide a systems model that describes the dynamics of marine litter from source to sink. This model can be used to visualise the "lifecycle" of marine litter by tracking the various pathways that litter can take from the point of discard and through the system until it is eventually removed or decomposed. The model, represented schematically in Figure 1, provides a simplified view of the key parameters and processes that can be measured or inferred from an appropriately configured marine litter sampling strategy.

In summary, the model identifies a set of key state variables (rectangular boxes) that represent "pools" of material that are in dynamic flux within the system. These pools include Floating litter, Benthic litter and Beach cast litter. The size of the litter pools are defined in terms of quantities of material (e.g. tonnes of floating litter or the numbers of particular items) and thereby represent the sum total of material within the system under consideration.

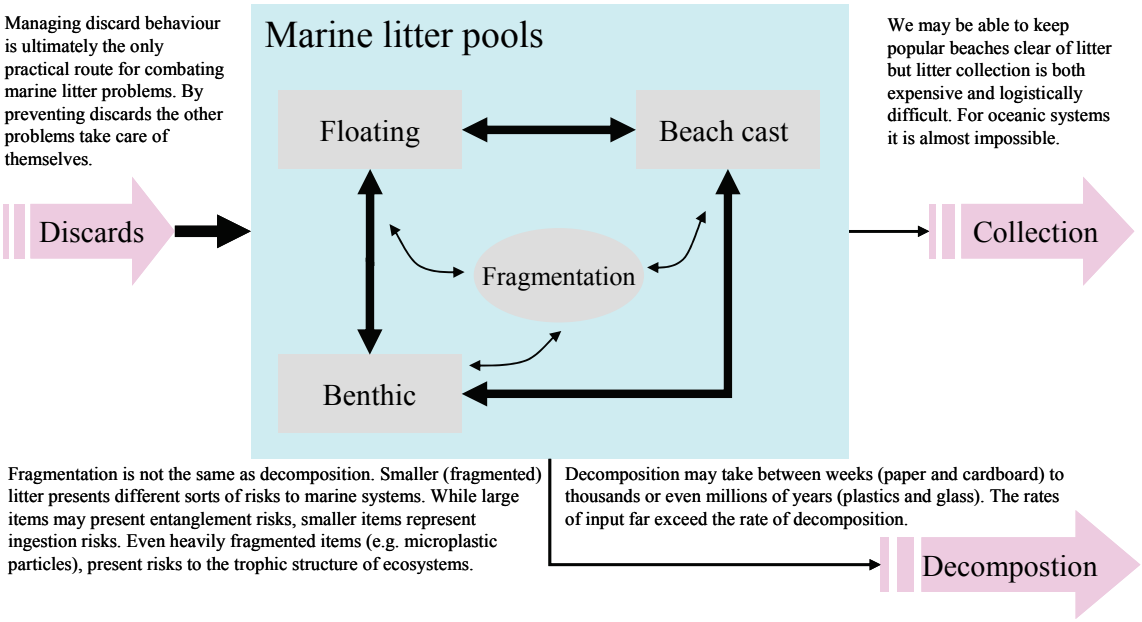


Figure 1. Schema representing the lifecycle of marine litter.

Dynamical processes (indicated in Figure 1 by arrows) illustrate the flux rates or movement of litter from one pool to another. These values are measured and reported as rate functions (e.g. tonnes of litter discarded per year or tonnes of litter being cast onto beaches per year). In general terms these flux rates can be measured either directly, by observation of amounts of material being transported, or indirectly through inferences based on changes in the amounts of litter in each pool over time.

The model can be used to illustrate some simple truths about the longterm options for the management of marine litter including:

1. For as long as the input processes (Discard) exceed the removal processes (Collection and Decomposition) then the amount of litter will increase through time resulting in more litter in the oceans and on the beaches.
2. Given that decomposition is slow (particularly for some of the persistent and more toxic plastic forms of litter) then this will never be a solution to the marine litter problem. In some cases material engineering may provide alternative materials that decompose more rapidly; increased rates of decomposition would then result in a reduction in the size of the litter pool.
3. The key point of control in the system is through the management of discard behaviours. If we can reduce inputs we have some chance of managing the downstream environmental consequences. Improvements are needed in waste management and reception facilities in ports and harbours, education of beach goers is essential to reduce domestic discards and improved management of rubbish dumps, particularly those in coastal catchments, are all required to reduce inputs to the system.

Management of marine litter can be informed by obtaining good quality data on the size of each of the pools and the rates of exchange between them. This allows us to articulate a set of useful objectives for any national or international programme of marine litter surveys. These being:

i) To provide information about the sources of different types of litter, and

ii) To quantify the amount of litter in different ocean systems.

To achieve these objectives, litter assessment guidelines must explicitly incorporate an awareness of the “life-cycle” of marine litter into the design, to support quantification of the key response variables and to allow an analysis of the efficacy of various management interventions.

In the absence of better management at source, the exponential growth of litter in the marine environment is certain to continue (Barnes 2002). The need to develop and evaluate alternative management strategies is therefore central if we aim to limit the amount of litter entering marine systems. In 1975, the annual influx rate of litter to the world’s oceans was estimated at six millions tonnes (National Academy of Sciences 1975) ; current rates are likely to be substantially greater. Given the prolonged timeframe for decomposition (UNEP 1990, The Ocean Conservancy 2006) and the very small amounts of litter actually removed through beach clearances (The Ocean Conservancy 2006), it can be argued that the volume of marine litter in the oceans will continue to increase exponentially over coming decades.

Chapter II. Establishing a framework for litter assessment

Introduction

To achieve better management outcomes in addressing the problems of marine litter there is a need to ensure that relevant, quality data are available to facilitate a comprehensive analysis of the nature and sources of litter and to quantify changes across regions, through time and in response to management interventions.

In this chapter guidelines are presented to support the establishment of a framework within which litter assessments (beach, benthic and floating litter) can be conducted. The primary objective is to establish a framework for managing the integration of individual litter assessment activities across broad geographical regions. In this context, regions may comprise sub- or supra-national areas where there is a unified system for coordinating and / or managing litter assessments. Typically regions may comprise UNEP regional seas areas that span national boundaries or, in the cases of countries such as Australia, national or sub-national programmes that cover management or planning areas.

The regional framework aims to support:

1) Quantification and characterization of marine litter for the purposes of developing and evaluating the effectiveness of management, control, enforcement and/or mitigation strategies in particular integration with solid waste management.
2) Understanding of the level of threat posed by marine litter to biota and ecosystems.
3) Provision of comparable datasets to support national, regional and global assessments of marine litter.

Framework for developing operational guidelines

The methods (detailed in the following chapters) for beach, benthic and floating litter assessment have been developed from a number of existing survey protocols that collectively have a track record of application in various regions around the world. Significant amongst these were the OSPAR, NOWPAP and the NMDMP protocols (Appendix B) which collectively provide:

1) Proven frameworks for delivery of long term, large scale marine litter surveys using trained (although often voluntary) survey participants.
2) Frameworks that support the development of litter summaries at a variety of spatial and temporal scales.
3) Methodologies that collectively satisfy most of the key criteria detailed in the comparative analysis of the alternative survey protocols (Appendix B).
4) Methodologies that are rigorous but still flexible enough to encompass a range of different litter management objectives.
5) Methodologies that have the capacity to address quality assurance and quality control issues.

Litter assessments need to be planned to ensure that they sit within and across the context of a broader regional management framework (Figure 2) and are delivered consistent with the defined protocols. In turn, these protocols need to include the definition and specification of the survey location, choice of sampling units, methodology for collection, classification and quantification of litter and a process for data integration, analysis and reporting of results.

Three aspects of this framework need to be structured to ensure integrity across regions and to support national, regional and global analysis of litter data. These are:

1. Effective and culturally appropriate systems for the recruitment and training of field staff and / or volunteers.
2. Establishment of a system for selecting litter survey sites at national and regional levels; and
3. Standardisation of the system used to classify and quantify litter (to support comparisons over broad regional and global scales.

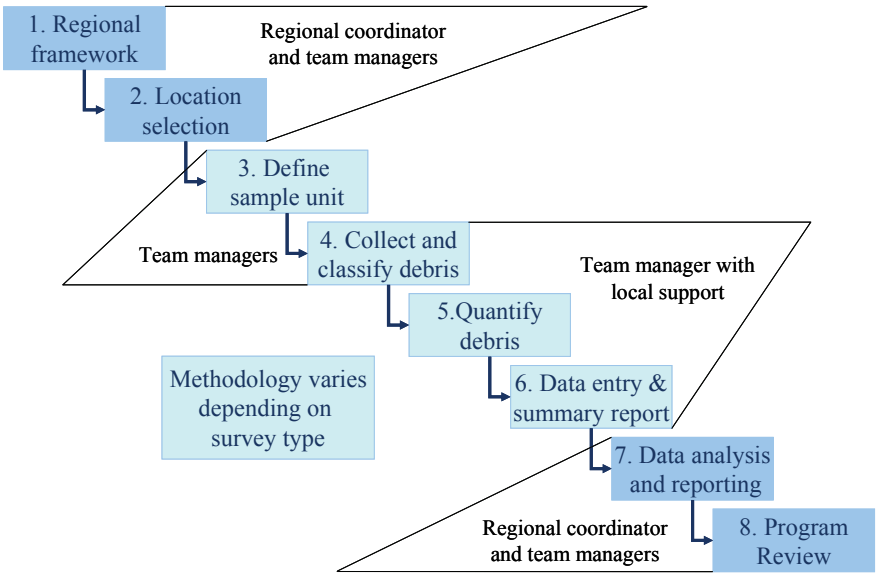


Figure 2. Steps in developing a marine litter assessment.

Recruitment and management of staff and volunteers

Any long term marine litter assessment programme will require a specific and focussed effort to recruit and train field staff and volunteers. Consistent, high quality training is essential to ensure data quality and needs to explicitly include the development of operational (field based) skills. Staff education programmes should incorporate specific information on the results and outcomes from the work so that staff and volunteers can understand the context of the litter assessment programme.

Whereas most guidelines (AMDS, NMDMP, NOWPAP – Beach, OSPAR, CCAMLR, CCI and NDNHI) recommend the use of the same personnel in all surveys through a programme, the maintenance of volunteer enthusiasm and continuity can be quite difficult (especially for long running – 5 – 10 year programmes) with a concomitant need to find and train replacement field teams (Sheavly 2007).

Sheavly (2007) concluded that while volunteers were effective, efficiencies could be greatly enhanced through integration of the sampling within local resource management programmes. This could include support from national parks, resource managers, fisheries and tourism managers as well as non-government organizations.

In developing a programme it needs to be recognized that volunteers typically come from a wide variety of backgrounds; by way of example the NMDMP volunteers included retired corporate executives, technicians, educators, local conservation organizers, middle and high school science classes, college students, U.S. Naval and Coast Guard offices and other members from the private sector (Sheavly 2007).

This diversity will bring with it differences in knowledge and experience and these need to be addressed when developing a volunteer programme. In summary there are a number of key issues that need to be considered when engaging volunteers in marine litter assessments and these include (adapted from Sheavly 2007):

i. Volunteers need to be properly trained with hands-on training exercises and supportive training materials and programme manuals that detail responsibilities and procedures.
ii. Local coordination and management is needed to ensure that volunteers are available when needed and monitoring schedules are followed.
iii. Effective and frequent communication is a key element in keeping volunteers engaged and up-to-date with the programme activities, including how their monitoring activities are supporting resource and conservation management efforts.
iv. Succession plans are needed to ensure that as some volunteers retire or leave the programme, new volunteers are trained to provide replacements.
v. Regular recognition efforts of the volunteers and their efforts can be effective in maintaining their involvement in the monitoring programme (e.g. media coverage, presentations by monitoring

group members and/or management groups at local civic meetings, thank you notes, various memorabilia including t-shirts, hats, etc.).

vi. The monitoring programme needs to be realistic in terms of the expectations of labour and the length of time needed to conduct this type of study.
vii. Programme managers need to make regular visits to sites to ensure that training is relevant and appropriate to the needs of the survey. Ideally follow-up visits should be scheduled to coincide with re-training efforts and other activities.
viii. Volunteer managers, who may often be volunteers themselves, need appropriate training to ensure that they have the skills to manage a volunteer workforce.
ix. Ideally local partnerships may be developed with state or municipal agency staff to facilitate the monitoring and integration of volunteer management, training and programme delivery.
x. Where appropriate, typically for remote surveys or where local people are limited by financial or other resources, monetary support may be required to cover transportation expenses related to their efforts.
xi. While the very nature of a volunteer is not to expect anything in return for his/her efforts, people do like to know that their efforts are meaningful and appreciated.

In more general terms the following issues are also relevant when managing volunteer programmes (adapted from the “Model Code of Practice for Organisations Involving Volunteer Staff”; Volunteering Australia 2007):

i. Interview and employ volunteer staff in accordance with anti discrimination and equal opportunity legislation;
ii. Provide volunteer staff with orientation and training;
iii. Provide volunteer staff with a healthy and safe workplace;
iv. Provide appropriate and adequate insurance coverage for volunteer staff;
v. Define volunteer roles and develop clear job descriptions;
vi. Differentiate between paid and unpaid roles;
vii. Provide appropriate levels of support and management for volunteer staff;
viii. Provide volunteers with a copy of policies pertaining to volunteer staff;
ix. Provide all staff with information on grievance and disciplinary policies and procedures;
x. Acknowledge the rights of volunteer staff;
xi. Offer volunteer staff the opportunity for professional development;
xii. Reimburse volunteer staff for out of pocket expenses incurred on behalf of the organization;
xiii. Treat volunteer staff as valuable team members, and advise them of the opportunities to participate in agency decisions; and
xiv. Acknowledge the contributions of volunteer staff.

All large scale marine litter surveys also have manuals and/or field guides to assist volunteers, most notable are those developed for the ICC and NMDMP (The Ocean Conservancy 2002, US Environment Protection Agency 2002, Sheavly 2007).

Field guides and litter identification tools are an important element in the maintenance of sampling consistency. Importantly, care should be taken to ensure that the development of guides is sensitive to language and cultural issues. For example, guides for surveys involving indigenous Australians should contain warnings that they may include images or the names of deceased persons. Issues of this nature highlight the need to obtain the support of locally based managers as the point of liaison between volunteers and higher level survey management.

Framework for selecting survey locations

Identification of appropriate sampling “locations” (Step 2 in Figure 2) is a precursor to establishing the basic sampling units within any litter survey programme. Accordingly, there is a need to consider the process by which survey locations are chosen. Ideally locations should be selected with reference to regional management or resourcing arrangements as well as their utility in providing meaningful data about litter dynamics. Typically, management arrangements will not only consider larger regional scale assessments but in most cases, will also need to address the requirements at smaller scales (sub-regions and countries or other geographical sub-divisions).

Regions, for the purposes of litter assessments, are best defined as large domains wherein management arrangements can be relied upon to provide broad coordination of litter survey programmes. Globally a variety of such domains already exist including international networks (e.g.

the UNEP Regional Seas Programme Areas (RSPA); Figure 3) and national networks such as those that define the sampling programmes for the NMDMP in the USA or the proposed arrangements for implementation of the AMDS in Australia (see e.g. Figure 3).

Regional coordinating units (RCU) associated with the various Regional Seas Programme areas (see glossary) currently manage marine litter investigations such as those operating in the NOWPAP, COBSEA and MAP regions. Elsewhere, regional or national coordinators manage the OSPAR, NMDMP and CCAMLR programmes.

For larger countries it may be necessary to sub-divide the coast to align with management arrangements. In Australia, for example, the AMDS programme (Cheshire and Westphalen 2007) has identified eight principal marine planning zones (Figure 3) whilst in the USA the NMDMP identifies nine coastal sub-regions (Sheavly 2007). Conversely, smaller nations (such as the small island nations in the Caribbean) might contribute survey data to a broader framework based on marine ecosystem boundaries. In such cases, although individual countries may only have a single sampling location, ideally all countries within a region will have at least one sampling location to contribute to regional programmes.

a) **b)**

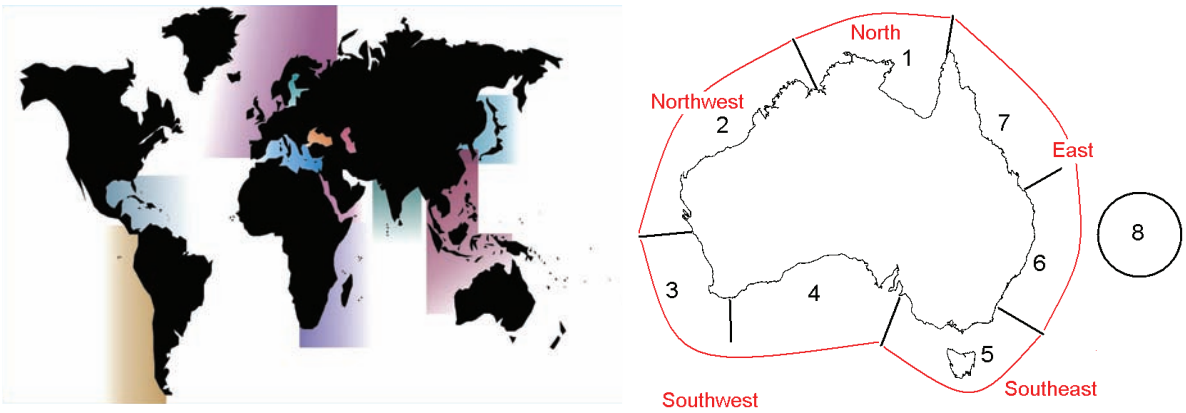


Figure 3. Alternative management arrangements including a) Regional Seas Programme Areas or b) Australian Bioregional Planning areas. Such programmes could be used to establish a framework for the management (and analysis and integration of results) of comprehensive regional beach litter assessments.

To be useful in delivering both regional and local scale coordination the management framework needs to be able to support the collection of meaningful data across countries and broader regions as well as to accommodate a degree of overlap in operational management, data structures and the management questions being addressed.

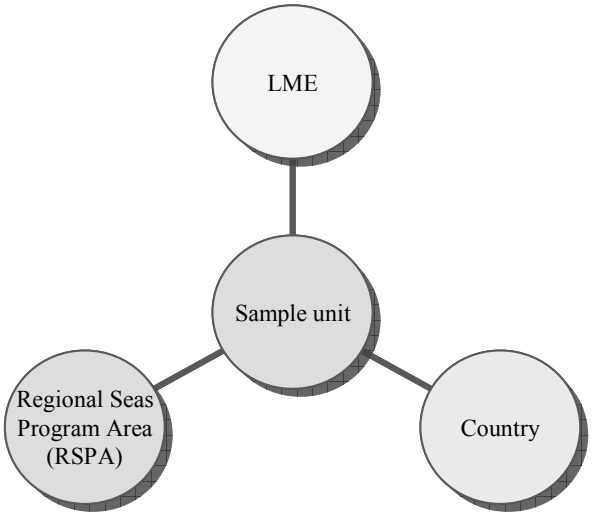
The broader framework for litter surveys may thus be realized through cross-linking the fundamental sampling units (i.e. beaches or other near-shore locations) within classes based on their representation of broader geopolitical regions/sub-regions as well as across countries and/or Large Marine Ecosystem (LME) areas.

Such a structure can be accommodated within a data integration and analysis system using a relational database structure where “Sampling units” represent the core (unique) element and information about national, regional or LME membership comprise descriptors for each sampling unit (Figure 4).

The use of a relational database approach to manage the information will then permit analyses to be conducted by aggregating and summarising data against any of these criteria (i.e. by Region, Country or LME; Figure 4). In the example shown (Figure 2; Figure 4) an analysis by RSPA would include data from all 3 sample units (they are all within the COBSEA area) whereas an analysis by LME would only include the Thailand and Malaysian samples (Bay of Bengal LME) with the Australian sample being analysed separately as part of the NW Australia Shelf Seas LME.

Ideally regional coordinators would be appointed to work across regions which may be either the RSPAs or National Programmes depending on the size and number of sample units being managed. The regional coordinator would have responsibility for managing the data obtained from sampling units within that management area. This person would also be responsible for the recruitment of location managers (see below), data integration and they may also provide support for volunteer training and/or community education.

Overall a management structure incorporating clear lines of communication to and from the centralised management agency is critical to the development and maintenance of a larger scale survey (Sheavly pers. comm.). Accordingly, location managers would need to work closely with a centralised management organization (e.g. Ocean Conservancy in the case of the NMDMP) to ensure effective outcomes.



Illustrative data table

Sample unit	LME	RSPA	Country
Mai Khao Beach, Phuket	Bay of Bengal	COBSEA	Thailand
Broome Beach, Western Australia	NW Australian Shelf	COBSEA	Australia
Tanjung Rhu Beach, Langkawi	Bay of Bengal	COBSEA	Malaysia

Figure 4. Schematic data relationships with illustrative data table – Sample units (i.e. beaches or near-shore locations) form the central data entity while information about Large Marine Ecosystems (LME), Regional Seas Programme Areas (RSPA) or Country are additional elements related to each sample unit and used to facilitate analyses with different geographical perspectives (e.g. based on LME or RSPA).

Framework for litter classification

The second major element of any regional framework is the adoption of a unified system for classifying litter items. Such a system will be a requisite part of any attempt to develop national or regional syntheses of litter data.

In broad terms existing survey protocols fall into one of three types:

1. Low resolution surveys that distinguish 1-6 different litter categories as seen in the two operational and floating litter surveys (CCI, FAP and Japan Floating);

2. Medium resolution surveys (30-60 litter categories) used in most other surveys (NMDMP, NOWPAP – Benthic, KMMAF, CCAMLR and WWF); and

3. High resolution (90 + litter categories) used in three surveys; the AMDS, OSPAR and NOWPAP – Beach survey protocols (the latter using the NPEC data sheets)[4].

From a research perspective, it can be argued that a higher resolution in litter classification (i.e. the classification of litter into a greater number of discrete classes) will provide the best opportunity to analyse and interpret data. Conversely, a fewer number of classes is likely to result in a lower error rate and therefore provide more consistency in data collection as well as making it easier to train and support survey staff and volunteers.

In these guidelines, the system for litter classification has been chosen to ensure a good balance between resolution and operational efficiency. The recommended system comprises a two level hierarchy that identifies items firstly by material composition (e.g. plastic vs. glass vs. rubber, etc) and then by form (e.g. bottles vs. sheets vs. fishing nets, etc). This classification system comprises a list of 10 different material classes and a total of 77 discrete types of litter (Table 1).

Table 1. Litter classification system for all surveys where litter is collected or identified *in situ*; the Remote Litter Classes (RLCs) are further detailed in Table 3.

CLASS	MATERIAL COMPOSTION	LITTER CODE	LITTER FORM (and examples)	RLC
1	Plastic	PL01	Bottle caps & lids	RL01
2	Plastic	PL02	Bottles < 2 L	RL02
3	Plastic	PL03	Bottles, drums, jerrycans & buckets > 2 L	RL03
4	Plastic	PL04	Knives, forks, spoons, straws, stirrers, (cutlery)	RL26
5	Plastic	PL05	Drink package rings, six-pack rings, ring carriers	RL11
6	Plastic	PL06	Food containers (fast food, cups, lunch boxes & similar)	RL09
7	Plastic	PL07	Plastic bags (opaque & clear)	RL15
8	Plastic	PL08	Toys & party poppers	RL27
9	Plastic	PL09	Gloves	RL25
10	Plastic	PL10	Cigarette lighters	RL20
11	Plastic	PL11	Cigarettes, butts & filters	RL19
12	Plastic	PL12	Syringes	RL18
13	Plastic	PL13	Baskets, crates & trays	RL06
14	Plastic	PL14	Plastic buoys	RL04
15	Plastic	PL15	Mesh bags (vegetable, oyster nets & mussel bags)	RL25
16	Plastic	PL16	Sheeting (tarpaulin or other woven plastic bags, palette wrap)	RL16
17	Plastic	PL17	Fishing gear (lures, traps & pots)	RL06
18	Plastic	PL18	Monofilament line	RL07
19	Plastic	PL19	Rope	RL08
20	Plastic	PL20	Fishing net	RL05
21	Plastic	PL21	Strapping	RL17
22	Plastic	PL22	Fibreglass fragments	RL23
23	Plastic	PL23	Resin pellets	RL23
24	Plastic	PL24	Other (specify)	RL23
25	Foamed Plastic	FP01	Foam sponge	RL13
26	Foamed Plastic	FP02	Cups & food packs	RL09
27	Foamed Plastic	FP03	Foam buoys	RL04
28	Foamed Plastic	FP04	Foam (insulation & packaging)	RL13
29	Foamed Plastic	FP05	Other (specify)	RL13
30	Cloth	CL01	Clothing, shoes, hats & towels	RL25
31	Cloth	CL02	Backpacks & bags	RL25
32	Cloth	CL03	Canvas, sailcloth & sacking (hessian)	RL25
33	Cloth	CL04	Rope & string	RL08
34	Cloth	CL05	Carpet & furnishing	RL25

[4] Note that the Hawaiian benthic survey method (NDNHI) uses 250 litter categories, but these relate to the diversity of derelict fishing nets that were the specific target of that survey. Similarly, the Net Kit employed in Northern Australia as part of the WWF survey protocol (now operated by NRETA) contains more than 180 different net types that may be identified within litter collections (White et al. 2004).

CLASS	MATERIAL COMPOSTION	LITTER CODE	LITTER FORM (and examples)	RLC
35	Cloth	CL06	Other cloth (including rags)	RL25
36	Glass & ceramic	GC01	Construction material (brick, cement, pipes)	RL23
37	Glass & ceramic	GC02	Bottles & jars	RL02
38	Glass & ceramic	GC03	Tableware (plates & cups)	RL26
39	Glass & ceramic	GC04	Light globes/bulbs	RL22
40	Glass & ceramic	GC05	Fluorescent light tubes	RL21
41	Glass & ceramic	GC06	Glass buoys	RL04
42	Glass & ceramic	GC07	Glass or ceramic fragments	RL23
43	Glass & ceramic	GC08	Other (specify)	RL23
44	Metal	ME01	Tableware (plates, cups & cutlery)	RL26
45	Metal	ME02	Bottle caps, lids & pull tabs	RL01
46	Metal	ME03	Aluminium drink cans	RL10
47	Metal	ME04	Other cans (< 4 L)	RL10
48	Metal	ME05	Gas bottles, drums & buckets (> 4 L)	RL03
49	Metal	ME06	Foil wrappers	RL09
50	Metal	ME07	Fishing related (sinkers, lures, hooks, traps & pots)	RL06
51	Metal	ME08	Fragments	RL23
52	Metal	ME09	Wire, wire mesh & barbed wire	RL29
53	Metal	ME10	Other (specify), including appliances	RL23
54	Paper & cardboard	PC01	Paper (including newspapers & magazines)	RL14
55	Paper & cardboard	PC02	Cardboard boxes & fragments	RL14
56	Paper & cardboard	PC03	Cups, food trays, food wrappers, cigarette packs, drink containers	RL09
57	Paper & cardboard	PC04	Tubes for fireworks	RL27
58	Paper & cardboard	PC05	Other (specify)	RL23
59	Rubber	RB01	Balloons, balls & toys	RL27
60	Rubber	RB02	Footwear (flip-flops)	RL25
61	Rubber	RB03	Gloves	RL25
62	Rubber	RB04	Tyres	RL28
63	Rubber	RB05	Inner-tubes and rubber sheet	RL28
64	Rubber	RB06	Rubber bands	RL23
65	Rubber	RB07	Condoms	RL18
66	Rubber	RB08	Other (specify)	RL23
67	Wood	WD01	Corks	RL23
68	Wood	WD02	Fishing traps and pots	RL06
69	Wood	WD03	Ice-cream sticks, chip forks, chopsticks & toothpicks	RL12
70	Wood	WD04	Processed timber and pallet crates	RL24
71	Wood	WD05	Matches & fireworks	RL12
72	Wood	WD06	Other (specify)	RL23
73	Other	OT01	Paraffin or wax	RL23
74	Other	OT02	Sanitary (nappies, cotton buds, tampon applicators, toothbrushes)	RL18
75	Other	OT03	Appliances & Electronics	RL23
76	Other	OT04	Batteries (torch type)	RL23
77	Other	OT05	Other (specify)	RL23

It should be noted that the classification system in Table 1 can be adapted for use in surveys where more detailed litter classifications are currently applied (e.g. OSPAR). This can be effected simply by using the litter code shown in Table 1 and then adding a decimal identifier to provide for further subdivisions of these classes. For example it may be desirable to differentiate vegetable bags from oyster or mussel bags (Code PL19). This could be done by assigning code PL19.1 to vegetable bags and PL19.2 to mussel or oyster bags. Providing this nomenclature is documented in the database then it will not impact on the overall data quality of the system.

The litter code associated with each of these different types of litter will need to be used to record information on all data sheets (see e.g. Table 2; except for remotely observed litter data where the codes in Table 3 should be used instead). Litter codes are recorded on the sheet along with information about the amount of each item collected. If for example a survey results in the collection of 25 plastic bottles (comprising 20 small, < 2L and the remaining large), 4 light globes, 10 cardboard fast food trays and 3 mesh vegetable bags then the data would be recorded as shown in Table 2.

Table 2. Illustrative section of data sheet used to record litter items collected.

LITTER DATA (continue over page if more space required)

Item code (standard list)	Description	Count (# items)	Weight (kg)
PL02	Plastic bottles small	20	0.86
PL03	Large bottles, 2 stroke oil containers	5	0.67
GC04	Light globes	4	0.2
PC04	Paper trays	10	0.35
PL19.1	Vegatable bags	3	.18

In developing a regional framework the litter data can be further augmented with information about the sources of the litter in the environment. This is best achieved using a relational data structure (similar to that used to record location) with litter code as the core piece of data and additional information about material composition, form and source recorded in parallel.

Where litter is observed remotely, for example in some benthic or floating litter surveys, the classification needs to be simpler because it is often impossible to distinguish items based on material composition. A floating bottle may for example be made of plastic or glass but it may not be possible to determine which simply by seeing it in the water from a distance. In such cases a less resolved classification system is recommended using the Remote Litter Classes (RLCs) that are principally based on the type of object (Table 3). Note that all litter items identified in Table 1 can be placed into one of the RLC categories (Table 3).

Table 3. Codes used to classify litter items that have been observed remotely (RLC)

General class	RLC	LITTER TYPE and examples
Containers	RL01	Bottle caps, lids & pull tabs
	RL02	Bottles < 2 L
	RL03	Bottles, drums & buckets > 2 L
Fishing & Boating	RL04	Buoys
	RL05	Fishing net
	RL06	Fishing related (sinkers, lures, hooks, traps, pots & baskets/trays)
	RL07	Monofilament line
	RL08	Rope
Food & Beverage	RL09	Cups, food trays, fast food wrappers & cardboard drink containers
	RL10	Drink cans
	RL11	Drink package rings
	RL12	Ice-cream sticks, chip forks, chopsticks, toothpicks, matches & fireworks
Packaging	RL13	Foam (insulation & packaging)
	RL14	Paper & cardboard
	RL15	Plastic bags (opaque & clear)
	RL16	Plastic sheet or plastic tarpaulin
	RL17	Strapping
Sanitary	RL18	Sanitary (nappies, tampon applicators, cotton buds, condoms, etc)
Smoking	RL19	Cigarette butts
	RL20	Cigarette lighters
Other	RL21	Fluorescent light tubes
	RL22	Light globes
	RL23	Other (specify)
	RL24	Processed timber
	RL25	Rags, clothing, shoes, hats & towels
	RL26	Tableware
	RL27	Toys
	RL28	Tyres & Inner-tubes
	RL29	Wire, wire mesh & barbed wire

Quantification of litter

Irrespective of how litter is classified, there is a need to develop a system for quantification in order to provide a basis for comparison between surveys.

Ideally, in situations where litter items are collected, both counts and weights should be recorded for all litter classes. Alternatively, it is recommended that the litter is weighed (and the quantity reported as kg). Recording both counts and weights allows for the broadest integration of data and avoids the obvious pitfalls (see below) with either type of measurement on its own.

If litter is not collected (and particularly for remote observations), then the amount of litter in each class should be quantified by counting items.

The relative merits of these two approaches for quantification are discussed below.

Weights of litter within categories

Weights of litter by categories are relatively easy to obtain and provide a very quick method for quantifying large numbers of items that have been collected during a survey. Furthermore, by aggregating items within a class and measuring the weight it is possible to rapidly deal with broken or fragmented material (e.g. glass bottles or plastic bags). In some cases (e.g. cloth or fishing net) the weight will be affected by whether the material is wet or dry and this is a source of error.

It needs to be recognized however that while a simple measurement of weight (e.g. that there is 100 kg of polyethylene sheet) quantifies how much material is present it is very difficult to relate this to management or the assessment of downstream risks unless you know what that 100 kg comprises in terms of individual items. If for example the 100 kg comprises 10,000 plastic bags each of which has the capacity to be ingested and kill wildlife then this represents a different scale of problem than if the litter comprises a single roll of material.

Similarly not all types of litter can be weighed, heavily fouled fishing nets or baulks of timber may weigh many tonnes. Practically these cannot be weighed unless the survey team has access to specialist equipment (that may not be routinely available[5]).

Counts of litter items within categories

Counts are relatively easy to make and they do not require any specialised equipment. In relation to litter items such as plastic drink bottles or plastic bags counts provide a quantitative indicator of relative importance. For remotely observed litter, counts within types are the only available approach.

Problems arise however when there are litter items within the same class that may differ substantially in terms of size. Counts of derelict fishing nets will grossly underestimate the significance of larger nets (Kiessling 2003) which may vary in size from less than 1 m^2 to 100s or even 1000s of m^2. In such cases counts are much less useful than a measurement of weight. Similarly counts are of very little use for quantifying heavily fragmented litter items. How, for example, do you count a hundred pieces of plastic bottle – is it equivalent to one bottle or many?

[5] Although it is acknowledged that in places such as northern Australia, where large fishing nets are ubiquitous in the beach cast litter, four wheel drive vehicles equipped with winches and lifting cranes are a standard piece of equipment used by survey teams. These vehicles allow collection of large items which may then be taken back to a central location for weighing and subsequent disposal.

Chapter III. Operational Guidelines for Comprehensive Beach Litter Assessment

Objectives for comprehensive beach litter assessments

Beach surveys have long been the primary tool for measuring the load of marine litter in coastal and marine systems and they also provide an invaluable mechanism for education and building community understanding and awareness.

Historically, surveys of marine litter accumulation on beaches have been the most commonly used method for estimating loads in the sea (e.g. Ribic *et al.* 1992, ANZECC 1996a, b, Rees and Pond 1998, Kiessling 2003, Stuart 2003), however, there has been a marked lack of consistency in sampling protocols and litter characterization (classification). To address this issue there is a need to develop and implement a standardized marine litter sampling protocol such that the amount of litter within our seas and oceans can be quantified and understood through long-term, broad scale, comparative studies (e.g. Wace 1995, ANZECC 1996b, Kiessling 2003, Stuart 2003, Edyvane *et al.* 2004, Cheshire and Westphalen 2007).

In this chapter guidelines are presented for comprehensive assessments of beach cast litter which have the following primary objectives.

1. Quantification and characterization of marine litter for the purposes of developing and evaluating the effectiveness of management, control, enforcement and/or mitigation strategies in particular integration with solid waste management.
2. Understanding the level of threat posed by marine litter to biota and ecosystems.
3. Providing comparable datasets to support national, regional and global assessments of marine litter.

In developing these objectives it needs to be recognized that data from surveys should be useful in addressing a number of fundamental questions about marine litter relating to the management, mitigation, sources and risks associated with litter in the environment (Table 4). In turn, such questions allow evaluation of the information collected from monitoring programmes and thereby assess its utility in supporting management responses.

Table 4. Key questions to be addressed through comprehensive beach litter monitoring programmes.

Monitoring Questions	Monitoring Parameters
Are management/mitigation strategies effective?	Litter Quantity (counts/weight) – changes through time.
What are the sources and activities leading to production of marine litter?	Litter categories (indicator items[6])
Is there a threat to marine biota and ecosystems?	Litter categories (indicator items[7])

[6] Indicators items for sources represent classes of items that are characteristic of certain types of users of the marine environment. For example cigarette butts are typically discarded by beach goers whereas oil containers by at sea operations including recreational and commercial boating.

[7] Indicators items for threats represent classes of items that may present specific risks to wildlife such as drink package rings or discarded fishing nets which present an entanglement risk whereas plastic bags present an ingestion risk.

Beach litter comprehensive survey operational guidelines

Comprehensive litter assessments need to be planned to ensure that they sit within the context of regional management frameworks (Chapter II). The key element in developing comprehensive beach litter assessments within the regional framework, is in the definition of “beaches” as the core sample unit.

The methodology for comprehensive beach surveys detailed below has been developed with reference to a number of existing survey protocols all of which have a track record of application in various regions around the world. Significant amongst these were the OSPAR, NOWPAP, NMDMP and AMDS protocols (Appendix B) which collectively provide:

1. Proven frameworks for delivery of long term, large scale marine litter surveys using trained (although often voluntary) survey participants.
2. Frameworks that support the development of litter summaries at a variety of spatial and temporal scales.
3. Methodologies that collectively satisfy most of the key criteria detailed in our comparative analysis of the alternative survey protocols (Appendix B).
4. Methodologies that are rigorous but still flexible enough to encompass a range of different litter management objectives.
5. Methodologies that have the capacity to address quality assurance and quality control issues.

It needs to be recognized that none of the existing protocols was deemed sufficient in its own right to qualify as the model for global adoption; instead we have adapted the best-practice elements from across the different survey protocols to ensure we have a system that fully addresses the requirements.

Beach selection and characterization

When undertaking beach litter assessments as part of a regional programme there is a need to:

1. Identify and select suitable beaches to allow the establishment of appropriate sampling units; and
2. To develop a survey schedule to ensure that data are collected as required over the lifetime of the study.

Ideally, at least 20 beaches should be selected per region, with a minimum of one beach in each of the representative countries. Note that replication of beaches (choosing more than one) within countries or even sub-regions is desirable.

Care needs to be taken to account for differences in the spatial intensity of the sampling programme between areas within a region.

Data from replicates should be aggregated and standardized by total length of beach surveyed, before any analysis that attempts to elucidate regional patterns.

Selection of beaches for marine litter surveys should follow the approach detailed in the NMDMP (which are similar to the OSPAR and AMDS criteria; Sheavly 2007, OSPAR 2007, Cheshire and Westphalen 2007), although the need for sandy beaches should be relaxed such that gravel beaches can also be included. The basic beach selection criteria (see e.g. Figure 5) should therefore include:

- A minimum length of 100 m (i.e. sufficient to fit the smallest sampling unit) although beaches with small amounts of litter may need to be longer (e.g. 1 km);
- Low to moderate slope (15 – 45º), which precludes very shallow tidal mudflat areas that may be many kilometres wide at low tide;

- Clear access to the sea (not blocked by breakwaters or jetties) such that marine litter is not screened by anthropogenic structures;

- Accessible to survey teams year round, although some consideration needs to be given to sites that are iced-in over winter and the difficulty in accessing very remote areas;

- Ideally the site should not be subject to any other litter collection activities, although it is recognized that in many parts of the world large scale maintenance cleaning is carried out periodically; in such cases the timing of non-survey related beach cleaning must be known such that litter flux rates (the amount of litter accumulation per unit time) can be determined (see sampling frequency below);

- Survey activities should be conducted so as not to impact on any endangered or protected species such as sea turtles, sea birds or shore birds, marine mammals or sensitive beach vegetation; in many cases this would exclude national parks but this may vary depending on local management arrangements.

- Although the NOWPAP and OSPAR selection criteria specify that sites should not be within close proximity to rivers, harbours and ports (NOWPAP 2007b, OSPAR 2007) it is recommended that within the above constraints, the location of sampling sites within each zone should be stratified such that samples are obtained from beaches subject to different litter exposures, including:

- Urban coasts (i.e. mostly terrestrial inputs);

- Rural coasts (i.e. mostly oceanic inputs);

- Within close distance to major riverine inputs.

Each survey location will require a location manager who is responsible for liaison with the regional coordinator as well as for recruiting survey volunteers, organising field operations, data collation and quality assurance sampling for each survey.

At each location data need to be collected relating to the depositional environment and proximity to litter sources including:

Aspect.

Prevailing wind (from meteorological data).

Beach curvature.

Total beach length.

Nearest river – name, distance, direction and whether or not it inputs directly to the beach.

Nearest town – name, distance and direction.

- Estimated number of person visits per year (based on a 10^n scale i.e. <10, <100, < 1,000 etc).

- Main beach usage (i.e. recreational – swimming and sunbathing, fishing, surfing, boat access or remote).

- Access (vehicular, pedestrian and/or boat only).

Beach slope should be measured at the start and end point of each transect.

The shape of the beach profile should be described at transect start and end points. A beach can be linear, concave, convex or sinusoidal/tiered in shape.

Figure 5. Long Beach near Robe in South Australia provides a good example of the type of beach that should be employed in a litter survey. Photograph G. Westphalen September 2007.

Offshore reefs and seagrass beds should be apparent while setting up each transect. However, this information should be checked against other sources because the difference between reef and seagrass beds may not be obvious.

Tidal distance should be measured as the linear distance from the highest strandline to low water level at the start and end of the sampling unit. Tidal range provides a basis for measuring slope, although very wide or flat beaches might prove difficult (hence the need for modest beach slope).

Tidal range should be obtained from published tidal data.

The back of the beach should be described in terms of the dominant features, be it dunes, vegetation or built structures (rock walls, road, path, fence, etc).

- Any other noteworthy information (e.g. an otherwise remote and unvisited location may be subject to an annual surfing competition that results in a “pulse” of litter).

This information only needs to be collated once for each site. Once recorded in the database the information will be used for all future surveys.

Much of this information can be obtained from maps and similar sources (e.g. Google Earth™ images), although such information should be checked by direct observation at the site.

Sampling units

Within regions the basic sampling unit for beach litter surveys is a fixed section (length) of beach from which measurements of litter load are made periodically. It is expected that survey teams will go back and re-survey the same sampling units over an extended period of time (e.g. every 3 months for a period of 5 or more years).

Data on litter from beach surveys will be analysed as the amount of litter (e.g. number of items, weight or volume) per unit length of beach per unit of time (generally the period since the last clean-up operation or survey).

Sampling units of 100-1000 m will achieve the most pragmatic balance between areal coverage and the amount of effort required to complete the survey within an acceptable time allocation (i.e. preferably less than three hours). There are good arguments for using both shorter and longer transects; in the OSPAR region for example, litter volumes on many beaches are such that it is not practical to sample more than 100 m of beach (although for larger litter items they use 1,000 m sampling units). In Australia it is common to use replicate 1,000 m sampling units because litter loads are generally much lower and therefore a single 1,000 m sample is unlikely to provide a good estimate for many beaches particularly those in remote areas (See Appendix B – Question 6: Sampling Units and Replication for more information as well as methods for determining the optimal length of sampling units).

Sample length is measured along the curve of the beach at the mid-point between the low tide mark and the back of the beach. Each sampling unit represents the entire area along each transect from the water's edge (preferably surveyed at low tide) to the back of the beach (Figure 6).

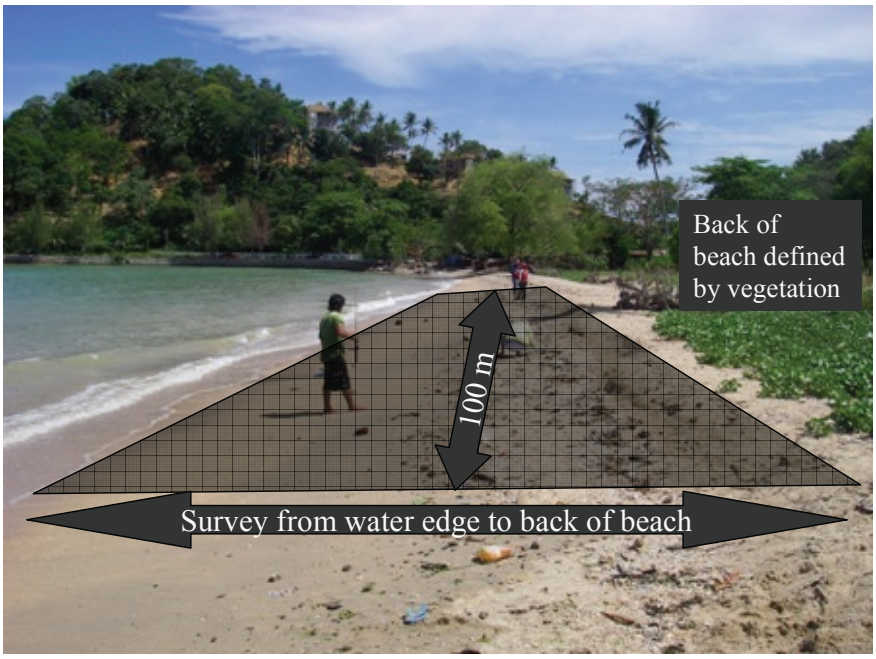


Figure 6. Relationship between a typical sampling unit and the beach on which it is positioned. All litter from the water's edge to the back of the beach is collected along the length of the sample unit (e.g. 100m).

The back of the beach needs to be explicitly identified using coastal features such as the presence of vegetation, dunes, cliff base, road, fence or other anthropogenic structures such as seawalls (either piled boulders or concrete structures).

Smaller sampling sub-units may also be employed for ubiquitous items such as cigarette butts but these do not form part of the standard methodology. Typically these sub-units should be 10 m wide strips from the water line to the back of the beach, preferably positioned at the start and end point for each larger transect where they are easily GPS referenced.

Additional requirements for a sampling unit include:

The start and end points of each sampling unit should be GPS referenced[8] and fixed for subsequent surveys. These points will also mark the location of any sub-units. Whereas

[8] Note that whenever GPS data are collected, the coordinate system and datum must also be explicitly stated.

the start and end points of the main transect can be marked with wooden stakes care should be taken to ensure that this does not contribute to litter in its own right. Ideally no equipment should be left on the beach.

1. If more than one sampling unit occurs on a beach the minimum separation distance shall be at least 50 m (although note the discussion about pseudo-replication and nested designs; see Appendix B – Question 6: Sampling Units and Replication).

Sampling frequency

An important distinction exists between survey protocols that estimate the flux rates of litter when compared with those that measure the standing crop of litter. Comprehensive surveys need to quantify not just standing crop but rather the flux rate (accumulation rate) of litter coming onto the beach. Flux rates are the preferred measurement[9] because they can be used as a proxy for estimating oceanic litter levels (Ribic et al. 1992, see also Appendix B).

In order to measure flux rates one must calculate the rate at which litter accumulates (i.e. the amount of litter arriving on a given length of beach over a given period of time expressed as [unit quantity of litter] per [unit length of beach] per [unit time]) as opposed to standing crop which measures the amount of material on the beach (i.e. [unit quantity of litter] per [unit length of beach]). This distinction between the assessment of flux rate rather than standing crop is one of the fundamental differences between the comprehensive and rapid assessment protocols.

The need to estimate flux rate has a direct influence on definition of the sampling frequency which, unless there are other cleaning programmes on beaches, will define the period over which the flux rate is calculated.

The minimum sampling frequency for any site should be annually. Ideally it is recommended that locations be surveyed every three months (allowing an interpretation of results in terms of seasonal changes). Quarterly sampling is consistent with the AMDS and OSPAR protocols (OSPAR 2006, Cheshire and Westphalen 2007). The NMDMP uses a monthly sampling regime (Sheavly 2007). Some consideration should be given to tropical regions where there are essentially only two seasons as well as high latitudes where access is likely to be restricted due to extreme remoteness and/or through being iced-in.

In order to obtain data on litter flux rates there is a need to undertake an initial beach clearance in order to remove all accumulated litter. This initial clearance will provide a clean slate against which future samples can be assessed. Data on litter may be collected from this clearance operation (which may serve as a training exercise), but this data cannot form a component of general analyses[10].

For beaches that have periodic maintenance cleaning, the timing of the survey should aim to maximize the subsequent interval. It is critical that the period of accumulation between clearances (be they for survey or maintenance cleaning) is known such that flux rates can be standardized (i.e. amount of litter per unit of beach per unit of time). It should be apparent that an advantage of using litter loads relative to beach length and accumulation time allows some flexibility in timing of surveys. However, given that beaches are in constant but often highly variable flux (either accumulating or degrading

[9] Standing crop (total amount of litter on a beach) relates to ocean litter load and time between clearances (either natural storm deposition and removal or human clean up operations). Conversely, flux rates (amount of litter arriving on a beach per unit time) are comparable to estimates of catch per unit effort in a fishery system and thereby provide a direct estimate of ocean litter load. It is important to recognize however that flux rates are difficult to calibrate because individual beaches may have very different depositional or remobilization characteristics and strictly speaking these factors need to be understood (or estimated) before comparisons between beaches can be made.

[10] The first clearance of a sampling unit can only provide data about standing crop. Flux rates can only be determined by measuring the amount of litter that arrives on a beach over a fixed period of time. By making an initial clearance the litter load is set to zero. A future survey can then estimate the litter load (e.g. kg/km) and, because the time interval since the beach was cleared is known, then this value can be transformed to a flux rate (e.g. kg/km/month).

and often both process occur simultaneously), care should be taken with respect to the sizes of the intervals being compared (i.e. the annual litter accumulation rate at a site will most likely not be the same as 12 times the monthly rate).

It is recognized that some litter survey methods rely on counting items but not removing them from the beach. In practice such an approach does not readily lend itself to estimates of flux rate but technically flux rates may still be calculated: the standing crop at the initial count would be recorded as the number of litter items per unit length of beach this number would be subtracted from the count per unit length at the next survey and the flux rate recorded as the change in number of litter items, per unit length of beach, per unit time.

Laying out a typical survey

Depending on the number of survey team members, the survey process can be undertaken in either of two ways (consistent with the NMDMP protocol; Sheavly 2007). Surveyors form skirmish lines either parallel to the coast (typically >5 persons) or at right angles to the coast (2-5 persons; Figure 7 a and b respectively). In both cases there should be around 2 m between persons forming the line.

All litter, within the sampling unit, that is larger than 2.5 cm in the longest linear dimension should be collected into carry bags. Smaller litter items that may be very common, such as cigarette butts, can be considered in 10 m wide sub-units at the start and end of each transect (if required; see sampling units above). Upon completion of the collection, the litter must be sorted into classes (see Appendix C) and quantitatively measured. On completion of the survey all should be disposed of appropriately, ideally by transport to a properly managed waste reception facility. Where possible, facilities that undertake to recycle wastes should be selected preferentially.

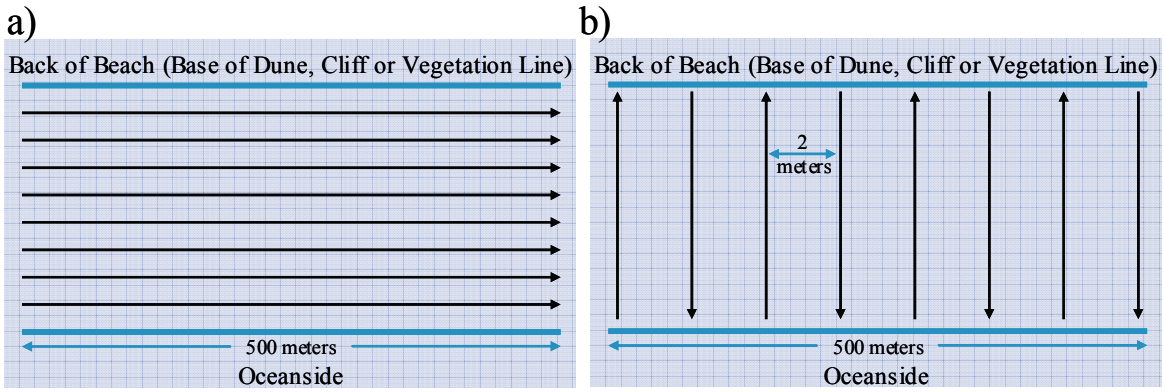


Figure 7. Beach litter surveys can be undertaken in either of two ways; a) surveyors form skirmish lines parallel to the coast (> 5 persons) or b) surveyors form skirmish lines at right angles to the coast (2-5 persons). In both cases there should be around 2 m between persons forming the line with each person responsible for noting or collecting all litter in the area between themselves and the person on the adjacent line.

In addition to characterization of the litter, additional data that must be recorded at the time of the survey, include:

- Survey date.
- Survey start and end times.

- Date on which the transect was last cleaned either as a survey or as part of broader beach maintenance programme (this is critical to calculation of flux rates – see above).

- Distance along beach covered by the survey – this should be fixed for each location (see Appendix B on sampling unit sizes) but may vary if local conditions prevent survey of the entire sampling unit.

- Width of the beach at the time of the survey (which should be as close to low tide as is practicable) from the current water level to the back of the beach – this may be used to standardize litter per unit of beach area rather than per unit length of beach (and thereby provides a basis for converting data to the NOWPAP reporting format).

- Number of persons on the survey team – this should include the survey leader and the number of collectors and provides a measure of survey effort. People not engaged in directly assessing the beach should not be counted (i.e. support people engaged in litter sorting and those assigned the task of collecting heavy items should not be included in the count).

- Any large litter items that cannot be safely moved by the survey group (these should be separately marked – see below).

- Any other details deemed relevant to the survey. This might include:

    - Information on any entangled fauna encountered during the survey (details of the organism, nature of entrapment, live or dead).

    - Data on events that may not directly relate to the survey site (i.e. offshore storms, shipwrecks, shipping container losses) or alternatively land based activities that may result in litter such as festivals, car races, fishing competitions etc.

    - Conditions at the time of the survey that might affect the litter collection (e.g. cold, hot, rain, snow, high winds) through impacting on staff performance.

Large immoveable objects (abandoned cars, very large fishing nets, baulks of timber, etc) that cannot be moved by the surveyors should be recorded on an additional datasheet, with information collected on the nature and location (preferably GPS fixed) for each large item. This information will be submitted along with other datasheets to ensure that any large item is included only once in subsequent analyses. In addition, the item may be marked (preferably with paint), to indicate the item has been included (Wennecker pers. comm.).

Organization of the survey, collation and transfer of the datasheets, quality control sampling and liaison with regional coordinators should be conducted through the location manager.

Data sheets

Three data sheets have been developed for comprehensive beach litter assessments including:

1. Site characterization data sheet (BC01 – double sided) is used to record information on the depositional nature of the environment and proximity to local litter sources. This sheet only needs to be filled out once for each beach location.
2. Litter characterization data sheet (BC02 – double sided) is used to record survey specific data including categorization and measurement of litter. This is the basic datasheet to be filled in for every survey at each site.

3. Large items data sheet[11] (ML01 – single sided) is used to record data on litter items that cannot be removed. This sheet needs to be used for all such items to ensure that they are only counted once (i.e. for the survey during which they are first encountered even if this is the initial clearance survey). Subsequent surveys should be conducted with reference to previously collected data and ideally a summary of this information should be taken into the field to ensure that these items are not recounted.

Quality assurance

Quality assurance and quality control should be primarily targeted at education of the field teams to ensure that litter collection and characterization is consistent across surveys. Investment in communication and the training of the country/regional and local survey coordinators and managers is thus critical to survey integrity.

The use of a laminated pictorial field guide with examples of each litter type will assist survey team members (particularly volunteers) to be consistent in litter characterization. Such pictorial guides may also be published as field guides and made available over the web to increase consistency between survey teams working at more distant (remote) locations

Beach selection and sampling unit layout should be undertaken or ratified by the regional and/or country coordinator who will recruit (and work with) a series of local managers. The local manager must ensure that data are appropriately collected and make corrections/address issues without damaging the enthusiasm of volunteers.

The NMDMP quality assurance protocol required a percentage of all locations to be independently re-surveyed immediately following the scheduled clearance (Sheavly 2007). The collected litter from the follow-up survey could then be added to that of the main collection and may also be used to provide an estimate of the error level associated with the survey. This approach may be similarly employed as a component of these guidelines (and may use the same datasheets), wherein (where resources are available) the local manager undertakes the follow-up survey.

Data management platform

Data collation should be undertaken through an online, relational database management system[12] under the control and direction of the local managers. Responsibility for review and approval of uploaded data should be undertaken by the regional/country coordinator who will clarify any issues with local managers. This would ensure a high level of consistency within each region as well as create a hierarchy of quality assurance on data acquisition.

The use of such a system will also support comprehensive analysis of the data providing the opportunity to undertake statistically robust comparisons through time and between survey locations.

Equipment needs

Safety is a priority and all field teams need to be equipped with a comprehensive first-aid kit. Field team members need appropriate clothing and footwear, protective gloves, hats, sunscreen, wet weather gear, water and food. Major risks to personnel include exposure to heat or cold, stick injuries (e.g. hypodermic syringes) and muscle/joint injuries associated with bending and lifting. Remote operations must follow appropriate safety protocols to ensure personal safety for team members.

[11] The Large items data sheet (ML01) is used for all types of marine litter survey including surveys of floating or benthic debris. This data sheet may also be used for ad-hoc observations (e.g. aireal observations or ships of opportuinity) to record items of interest such as shipping containers or derelict fishing gear.

[12] The detailed design of an appropriately configured RDBMS is beyond the scope of this project but it should be noted that the NMDMP, OSPAR and AMDS programmes all have databases that have been designed or developed and any of which should be suitable with a modest level of customization. The key thing would be to ensure that litter classification (see below) and beach characterization data structures were appropriately modified to address the flexibility issues required of this system.

Survey coordinators should also take responsibility for securing beach access permits and other approvals that may be required from local management authorities.

Global Positioning Systems (GPS) are highly desirable, particularly in relocating and determining the length of sampling units. The systems available are increasingly affordable and accurate. In addition to a GPS (or as an alternative if a GPS is not available) a digital camera (e.g. mobile phone camera) can be used to provide images to support relocation of sampling units. In some cases it may be practical to physically mark sites using wooden stakes or marker poles although care must be taken to avoid damage to sensitive habitats. In addition to the above a detailed written description of the location of the site and key landmarks will facilitate future surveys.

Where litter weights are required, battery powered electronic balances with an operating range of 0-10 kg are now routinely available and ideal for weighing smaller collections of items. Spring balances are available with a range of weight ratings up to 50 kg (and possibly higher). These balances can be used in conjunction with a standard 11 L bucket (or similar) to hold material during measurements. Spring balances have the advantage that they do not require electrical power and they are generally accurate enough (to within 10%) for the purposes of litter characterization but they must be replaced frequently as the spring becomes rusted and worn.

Digital cameras may also be useful to photograph unknown items (if they are not collected) and to record extraordinary events (e.g. ship wrecks). General equipment requirements include collection bags, clip-boards, tape measures, stakes and flagging tape all of which are routinely available from most hardware stores.

A pocket calculator may be useful to sum weights that are collected in batches.

A sharp knife or shears is useful for cutting away entangled litter (rope, cable, fishing line and nets).

Access to remote areas cannot be achieved without appropriate (generally 4WD) vehicles. They have the added advantage that heavy items can often be loaded into the tray (particularly if they come equipped with lifting gear) or alternatively dragged to a collection point.

BEACH LITTER Beach Data Sheet BC01	Organization		Name of the organization responsible for collecting the data
	Surveyor Name		Name of the surveyor (person responsible for filling in this sheet
	Phone number		Phone contact for surveyor
Completed **ONCE** for each site	Date		Date of this update to the data

SAMPLING AREA

BeachID		Unique identity code for the beach (office use only)
Beach name		Name by which the beach is commonly known (include country)
Region name		Name for the region (office use only)
LME		Name for the LME in which the Beach is located (office use only)
Co-ordinate system		Datum and coordinate system used to record latitude and longitude

BEACH CHARACERISTICS – considered from the start point of the transect

Slope		Slope of the beach – distance for 1 m of fall from mid point of beach
Aspect		Compass direction perpendicular to the beach facing the sea (nnn degrees)
Prevailing wind		Direction of prevailing wind for the beach system (nnn degrees)
Beach curvature		Concave, convex, sinusoidal, straight
Horizontal profile		Horizontal shape of the beach (Linear, Concave, Convex, Mixed)
Total beach length		Length measured along the mid point of the beach (kilometres)
Substratum type		Defines whether predominantly a sandy or gravel beach (pebble, rock etc)
Substrate Uniformity		An indication of the coverage by the predominant substrate type (Percent)
Offshore reefs		Presence of offshore reefs (yes/no)
Offshore seagrass		Presence of offshore seagrass beds (yes/no)
Tidal range		Max – min vertical tidal range (metres)
Tidal distance		Horizontal distance (metres) from the lowest tide to back of the beach
Back of beach		Describe the landward limit (Rock wall, Cliff, Dune, Anthropogenic)

Terrestrial vegetation (describe if any)

Please turn over …

SOURCE CHARACTERISTICS – considered from the start point of the transect

Location & major beach usage	URBAN		Select one & indicate the major usage type (swimming and sunbathing, fishing, surfing, boat access or remote).
	PERI-URBAN		
	RURAL		
Estimated visitors per year			Estimate of number of persons who visit the beach annually on logarithmic scale (10n)
Access			Vehicular (can drive on beach), pedestrian (must walk), isolated (i.e. need a vessel)
Nearest town			Name of nearest town
Nearest town distance			Distance to the nearest town (kilometres)
Nearest town direction			Direction to the nearest town (degrees)
Nearest river name			Name of nearest river (if relevant) – a null value is assumed to mean no inputs to this location
Nearest river distance			Distance to the nearest river (or stream) (kilometres)
Nearest river direction			Direction to the nearest river or stream (degrees)
River/creek input to beach	YES	NO	Whether the nearest river or stream has an outlet directly to this beach (yes/no)
Pipes or drains input	YES	NO	Distance and direction (yes/no)

Notes

BEACH LITTER **Sample and Beach litter data** **BC02** Completed **ONCE** for each survey	Organization		Organization responsible for the survey
	Surveyor Name		Name of the surveyor (person responsible for filling in this sheet)
	Contact		Phone contact for surveyor
	Region		Name for the region
	BeachID		Unique identity code for the beach (office use only)

Sample unit information

Beach Name			Unique Name by which the beach is known
Latitude/longitude start			Recorded as nnn.nnnnn degrees at the start of the sample – indicate NSEW
Latitude/longitude end			Recorded as nnn.nnnnn degrees at the end of the sample – indicate NSEW
Coordinate system			Datum and coordinate system for latitude and longitude
Survey date			Date survey was started for the sample (generally today's date)
Time start/end			Time taken to complete the survey (h)
Season			Spring, Summer, Autumn, Winter, NE Monsoon etc
Date of last survey or cleaning			Date on which the beach was last cleaned either by survey or maintenance clean up
Storm activity			Has there been any significant storm activity since the last survey
Number of persons			Number of persons collecting litter
Sample unit length			Length of sample unit along the beach (m)
Width of beach			Width of beach at the time of survey (m)
Sub-units (if used)			Number and distance along beach
Quality assurance			Is the sample for quality assurance purposes (either YES or leave blank)
Large items	Collate data on large items using the ML01 datasheet		

LITTER DATA (continue over page if more space required)

Item code (standard list)	Description	Count (# items)	Weight (kg)	Item code (standard list)	Description	Count (# items)	Weight (kg)

Notes (e.g. entangled fauna, important events – storms, shipwrecks etc, conditions that may affect survey)

LITTER DATA continued …

Item code (standard list)	Description	Count (# items)	Weight (kg)	Item code (standard list)	Description	Count (# items)	Weight (kg)

Notes (e.g. entangled fauna, important events – storms, shipwrecks etc, conditions that may affect survey)

<table>
<tr><td rowspan="3">Marine LITTER
Large Items Data Sheet
ML01</td><td>Organization</td><td></td><td>Name of the organization responsible for collecting the data</td></tr>
<tr><td>Surveyor Name</td><td></td><td>Name of the surveyor (person responsible for filling in this sheet</td></tr>
<tr><td>Contact</td><td></td><td>Phone contact for surveyor</td></tr>
<tr><td rowspan="4">Use only for items that were not collected.
Complete survey data at top of form and then ONE row for EACH ITEM.

Use additional forms if required.</td><td>Date</td><td></td><td>Collection date for this data</td></tr>
<tr><td>Region name</td><td></td><td>Name for the region</td></tr>
<tr><td>LocationID</td><td></td><td>Unique code for the location</td></tr>
<tr><td>Coordinate system</td><td></td><td>Used for all GPS data on this page – provide datum and format</td></tr>
</table>

LARGE ITEM DESCRIPTION

Item type (If possible use standard codes)	Status (floating, sunken, stranded, buried)	Latitude (nnn.nnnnn NS)	Longitude (nnn.nnnnn EW)	Description

Operational Guidelines for Benthic Litter Assessment

Objectives for benthic litter assessments

A significant proportion of litter that enters the sea remains in the marine environment and much of this litter eventually sinks and accumulates on the seabed (termed as benthic litter; UNEP 2005). Benthic litter is rarely seen by the general public and therefore draws little attention or public reaction (Galgani et al. 2000). Nevertheless, this litter continues to pose numerous problems. It is as a potential navigation hazard, an impediment to trawl fishers (OSPAR 2006) and can lead to entrapment or smothering of sensitive marine biota (NOWPAP 2007a).

In this chapter guidelines are presented for comprehensive assessments of benthic litter which have the following primary objectives:

1. Quantification and characterization of marine litter for the purposes of developing and evaluating the effectiveness of management, control, enforcement and/or mitigation strategies in particular integration with solid waste management.
2. Understanding the level of threat posed by marine litter to biota and ecosystems.
3. Providing comparable datasets to support national, regional and global assessments of marine litter.

As with all marine litter, effective management of benthic litter requires good data on the sources of litter entering the marine environment, where it occurs and in what quantities. The following guidelines have been developed to provide a basis for such investigations.

Benthic litter trawl or towed survey operational guidelines

The methodology for benthic litter assessment has been developed with reference to the well established NOWPAP framework (NOWPAP 2007a) and also using information from the Hawaiian Ghost Nets Program (Donohue et al. 2001, Timmers et al. 2005). Two alternative assessment formats have been developed including methodologies for:

1. Benthic surveys using trawls or towed equipment including benthic trawls, camera tows, submersible surveys or side scan sonar; and
2. Diver visual assessment surveys in shallow water, near shore areas.

The NOWPAP programme provides advice about conduct of benthic trawl surveys while the US Hawaiian Ghost Nets Program has been considered in developing shallow water visual surveys. Substantive changes have been made to these methodologies to ensure that litter classification strategies are consistent with those being used for the other survey methodologies (see chapters on Beach and Floating litter assessments).

These methodologies were used as a basis for the operational guidelines because they represent:

1. Proven frameworks for benthic assessment; and
2. Methodologies that are rigorously defined but offer sufficient flexibility to encompass a range of different litter management objectives.

In the following sections the two alternative approaches to benthic survey have been outlined.

Benthic litter assessments need to be planned to ensure that they sit within the context of regional management frameworks (Chapter II) and are delivered consistent with the defined protocols. In turn, these protocols need to include the definition and specification of the survey location, choice of sampling units, methodology for collection, classification and quantification of litter and a process for data integration, analysis and reporting of results.

Benthic surveys that require towed equipment need to make explicit consideration of the potential environmental impact of the operation particularly as these relate to physical damage to benthic environments and the potential for by-catch. Although there is debate as to the nature and extent of environmental damage incurred by trawling operations (Collie et al. 2000), alternative approaches to gathering sunken debris should be considered. In particular, this should include engagements with the fishing industry along the lines of the “Fishing for Litter” programme employed in the North Sea

(OSPAR 2006). Indeed, given the expense and logistical issues associated with trawling operations, as well as legislative restrictions and/or licensing cost of benthic trawl operations in many countries, "Fishing for litter" programmes may be the only viable means of obtaining data on benthic debris in many systems.

Not withstanding, if benthic litter surveys, using trawls or towed equipment, are to be undertaken, a modified form of the NOWPAP (2007a) approach is recommended using the standardized litter classification system for material that has been either remotely observed (i.e. using cameras or side scan sonar) or material collected in trawl operations.

In many cases it may be possible to develop collaborative projects with researchers who undertake trawl operations for other purposes (e.g. fishery researchers). In such circumstances the survey supervisor will need to balance the logistic requirements of litter surveys against the cost of operating independently.

Given the nature of the equipment and technical expertise involved, it is understood that trawl surveys will not make extensive use of volunteers due to the liability and safety issues.

Regional considerations

Whereas the NOWPAP approach considers provinces within member states this should be aligned with the regional framework developed above (Chapter II). At least 20 sampling units will be selected within each region although a higher level of redundancy (i.e. replication) in sampling units within each region is highly recommended.

Data from replicates should be aggregated at the site level, and standardized by area surveyed, before any analysis that attempts to elucidate regional patterns.

Trawl site selection and characterization

Sites should be selected to ensure that they:

- Comprise areas with uniform substrate (ideally sand/silt bottom);
- Are of uniform depth;
- Focus on areas that are known to generate/accumulate marine litter;
- Avoid areas where there is a risk of unexploded munitions
- Avoid sensitive and/or pristine habitats that might be damaged by trawling operations;
- Are areas that would not impact on any endangered or protected species such as sea turtles, sea/shore birds or marine mammals.

Within the above constraints on site selection, sampling units should be stratified relative to sources within a region such that there are samples obtained from:

- Urban coasts (i.e. mostly terrestrial inputs);
- Rural coasts (i.e. mostly oceanic inputs);
- Within close distance to major riverine inputs;
- Offshore areas (major currents, shipping lanes, fisheries areas, etc.).

Sampling units

A sampling unit will comprise a fixed 5 km × 5 km survey area. The benthos in this area should be pre-surveyed using either side scan sonar or direct camera observations. This pre-survey will help determine the nature of the trawl gear to be deployed (e.g. nets or grapples) and should also be used to identify areas that need to be avoided (e.g. where benthic obstructions could impact on trawl operations). In setting up the pre-survey the area should be sub-divided into twenty five 1 km × 1 km sub-blocks which will be individually assessed for trawl suitability.

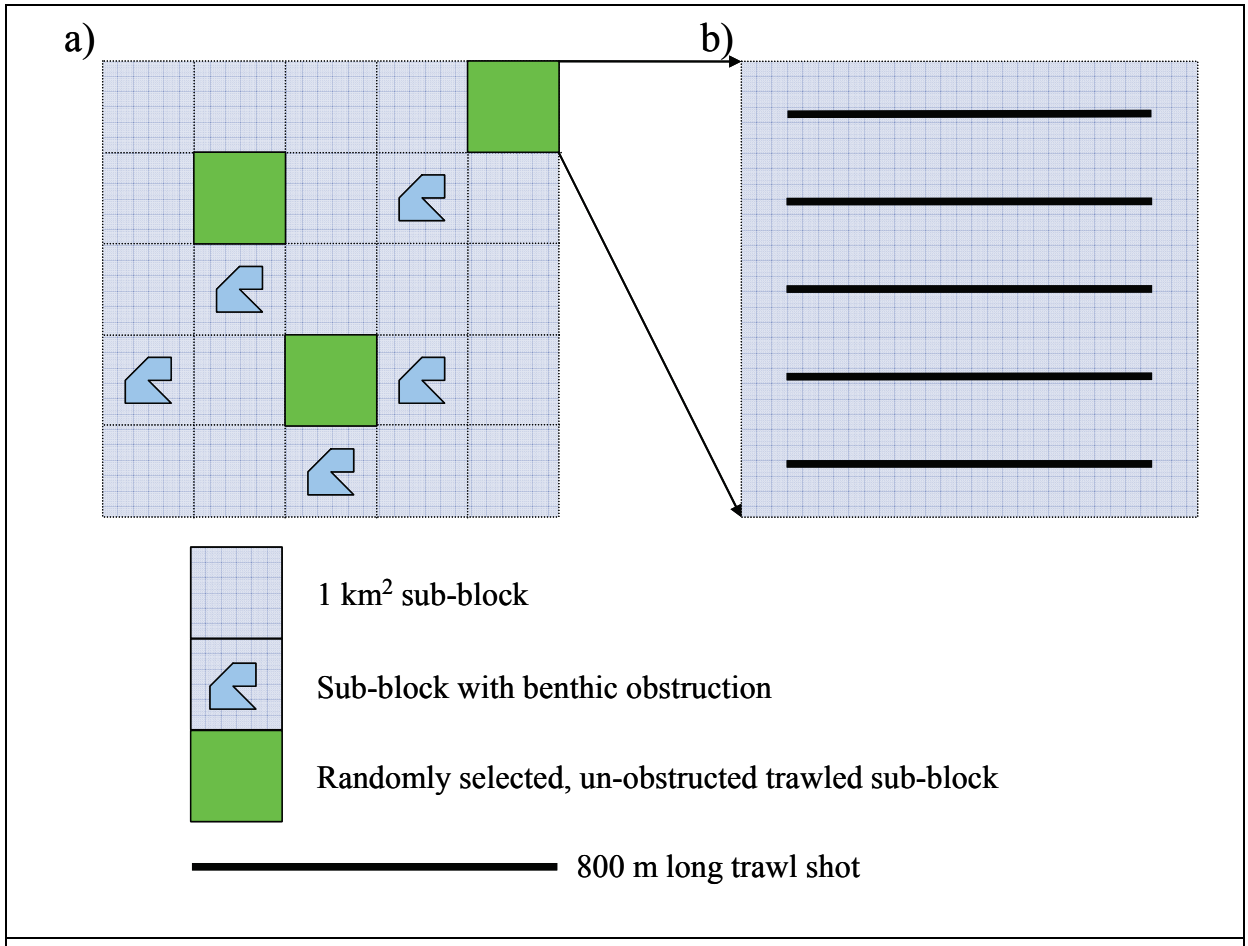


Figure 8. Layout of benthic trawl samples comprising 3 randomly chosen 1 km × 1km sub-blocks from a 5 km × 5 km sampling unit; a) the pre-survey identifies 20 sub-blocks that are suitable for trawling operations from which 3 random sub-blocks are selected for trawling; b) 1 km × 1 km sub-block showing location of 5 trawl shots.

Having identified which of the sub-blocks is suitable for trawling (candidate sub-blocks; i.e. those with no benthic structures or areas of conservation significance) a group of 3 sub-blocks should be selected for trawling. These 3 areas should be randomly selected from the candidate areas to ensure un-biased sampling of the 5 km × 5 km sample unit.

Trawl sub-samples

Once the three sub-blocks have been selected each can then be trawled using either nets or grapples (as appropriate given the nature of the litter). Trawl operations should be conducted such that:

- Ship speed should be restricted to 3-4 knots.
- Each sub-block should be trawled using five parallel trawl shots up to 800 m long.
- The ship should proceed in a straight line against the current, so that grapnel (hook) or trawl nets are spread out in a line astern.
- Trawl shots should be separated by a minimum of 200 m.

Data on all litter collected should be aggregated (summed) across all trawl shots and across all 3 sub-blocks. Data should be reported per unit length trawled (e.g. assuming shots of 800 m length and a total of five shots in each of the three sub-blocks this will equate to a total trawl length of 15 × 800 m or 12 km). Litter will then be reported as kg / km.

Note any unidentified or suspicious looking items should be treated with care as they may be unexploded munitions. Survey supervisors should consider this risk in survey planning.

Sampling frequency

NOWPAP (2007a) recommend that benthic surveys should be conducted annually. Given that the opportunity exists for some benthic litter surveys to be conducted in close geographical proximity (e.g. offshore) to beach survey sites, then the survey may be conducted at the same time as one of the beach surveys. This will then provide an opportunity for an analysis of the relationship between benthic litter loads and the flux of litter onto beaches.

Litter categories and measurement

Trawled litter should be classified using the standard categories (see data sheets below) and quantified using weights or number of items as appropriate.

Benthic litter classification can also occur in the pre-survey using observations from either camera or side scan sonar. However, it needs to be recognized that there will be a lack of precision in litter characterization where material is not collected (particularly for side scan sonar observations). In such cases litter will need to be classified using a subset of the standard classifications based on litter form (e.g. all bottles, cans, etc. lumped together regardless of composition – see Chapter II).

All litter that is collected should be disposed of appropriately ideally by transport to a properly managed waste reception facility. Where possible, facilities that undertake to recycle wastes should be selected preferentially.

Data sheets

Three data sheets have been developed in line with the above:

1. Site characterization data sheet (BL01 – single sided) is used to record information about the general area of the 5 km by 5 km survey location. This sheet records information on the nature of the benthic habitat and the proximity to likely litter sources. The sheet should be filled out only once for each location.

2. Trawl litter data sheet (BL02 – single sided) is used to record survey specific data including categorization and measurement of litter. This is the basic datasheet to be filled in for every trawl shot at each site. If multiple trawl shots are run at any given site then a new sheet should be used for each shot.

3. Large items data sheet (ML01 – single sided) is used to record data on litter items that cannot be removed. This sheet needs to be used for all items to ensure that such items are only counted once (i.e. for the survey during which they are first encountered). Before undertaking a re –survey of any site this information should be reviewed to ensure that the location of such items is known.

Data management platform

Data collation should be undertaken through an online, relational database system[13] under the control and direction of the local managers. Responsibility for review and approval of uploaded data should be undertaken by the regional/country coordinator who will clarify any issues with local managers. This would ensure a high level of consistency within each region as well as create a hierarchy of quality assurance on data acquisition.

Equipment needs

Equipment needs and operational logistics for trawl surveys are extensive and highly specialised (see NOWPAP 2007a and related references). The following are general requirements:

- Configuration of trawl equipment will be dependant on the type of seabed litter and geographical conditions; e.g. trawl nets can be of 2 cm mesh size, 2-4 m width, 1 m height and 20 m length; alternatively grapples or hooks may be used;

[13] The detailed design of an appropriately configured RDBS is beyond the scope of this project but it should be noted that the NMDMP, OSPAR and AMDS programmes all have databases that have been designed or developed and any of which should be suitable with a modest level of customization. The key thing would be to ensure that litter classification (see below) and beach characterization data structures were appropriately modified to address the flexibility issues required of this system.

- Rope length has to be determined depending on the water depth, specialist advice on setting a trawl should be obtained;
- Seabed litter should be taken on board with proper equipment such as side rollers;
- Litter can be sorted directly on board provided deck space is available, care should be taken to ensure safety of personnel through use of protective clothing including gloves;
- After collection and sorting, facilities are required to safely count and weigh litter; specialist lifting and weighing equipment may be required.

Benthic litter visual survey operational guidelines

Visual surveys of benthic litter provide a useful tool for quantification of litter particularly in near shore shallow water areas where litter may regularly become entangled with benthic structures such as rocky or coral reefs. Such assessments can be used to direct clean-up operations and may be an important tool in the management and protection of sensitive habitats (e.g. marine parks or reserves, spawning grounds, etc).

The key element, in developing shallow water visual surveys, is in the definition of underwater belt transects as the core sample unit. A belt transect is an area of the seabed delineated by a long central line (of fixed length e.g. 100 m) which is used as a guide for divers who then survey all litter within a certain distance (typically 2 m on either side) of the central line.

Regional considerations

At least 20 sampling units (i.e. 100 m belt transects; see below) will be selected within each region although replicate transects may be used to increase areal coverage and to provide a higher level of redundancy in sampling units.

Data from replicates should be aggregated at the site level, and standardized by area surveyed, before any analysis that attempts to elucidate regional patterns.

Visual survey site selection and characterization

Sites where belt transects are established should be selected to ensure that they:

1. Are at depths of less than 20 m deep for diver safety and bottom time considerations (based on a maximum non-decompression bottom time of ~ 50 minutes at 18 m depth according to DCIEM tables[14]). Beyond this depth remote methods (i.e. camera tows) should be used;
2. Focus on areas that are known to generate/accumulate marine litter;
3. Avoid areas of potential hazard to divers (e.g. shipping channels, areas with high currents, or seal breeding areas with associated shark attack risks);
4. Have ready access, from support vessel or from shore;
5. Are accessible all year round; if a site is not accessible due to weather or other circumstances then data can be adjusted during analysis.
6. Will not impact on any endangered or protected species such as sea turtles, sea/shore birds, marine mammals or sensitive beach vegetation.
7. Have known depositional characteristics and anthropogenic influences.
8. Within the above constraints on site selection, sampling units should be stratified relative to sources within a region such that samples are obtained from:

Urban coasts (i.e. mostly terrestrial inputs).

Rural coasts (i.e. mostly oceanic inputs).

Within close distance to major riverine inputs.

[14] Note divers should make their own assessment of bottom times after due consideration of their personal circumstances including experience level and previous diving history, consideration of repetitive dive profiles and personal susceptibility. DCIEM tables are commonly used for recreational/sport divers but individual needs should be assessed for any diving programme.

Sampling units

While the NOWPAP (2007a) method provides a good basis for diver surveys, the 10 × 10 m sampling units recommended in these are probably too small to achieve representative coverage. Conversely, the manta tow approaches used in the Hawaiian ghost net survey (Donohue et al. 2001, Timmers et al. 2005) are more representative spatially, but lack the capacity to deal with small litter items.

As a consequence, the method for laying out the benthic surveys using divers has been modelled on the standardized fish visual census methodology developed through the ASEAN-Australia Living Marine Resources Program (English et al. 1997). This method has proven very reliable for fish surveys and is considered to have direct utility for litter. This methodology is operationally very similar to that described for beach surveys.

The major challenge for a diver survey is locating and swimming the correct transect line and distance. A sampling unit (Figure 9) will comprise:

A 100 m (or longer) belt transect that is run at a fixed depth parallel to shore.

Distances should be determined either by laying out a 100 m tape measure or alternatively by laying a 100 m length of weighted rope across the bottom. The latter can be deployed and retrieved from a boat. String lines like those used by cave divers may also be employed.

The start and end point of the transect should be identified with marker buoys and recorded using a GPS.

Pairs of divers swim in parallel along either side of the tape/rope/string noting all litter items found within 2 m either side of the transect line. If visibility is less than 2 m then surveys should not be attempted.

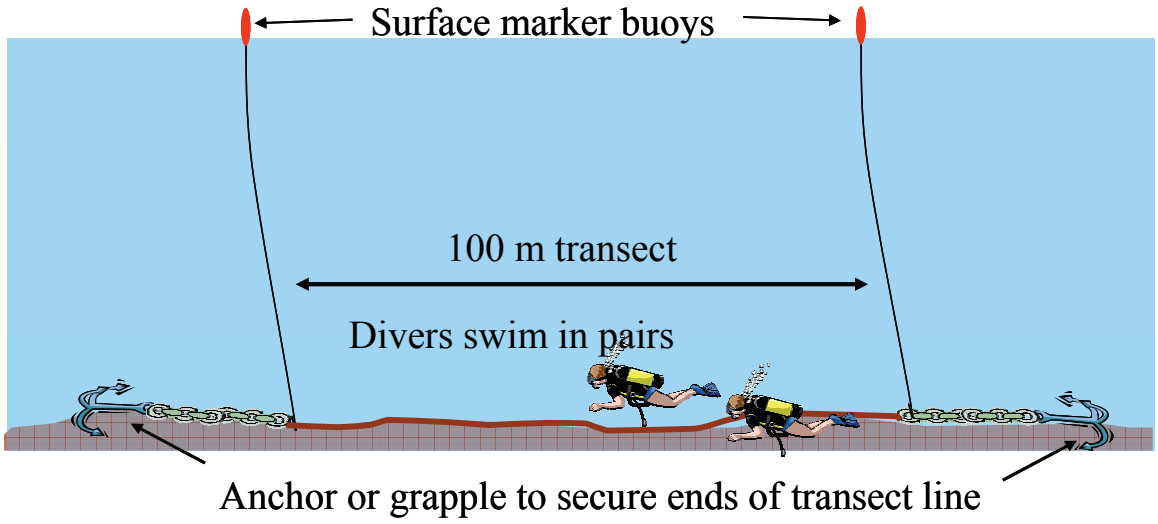


Figure 9. Layout for benthic visual litter survey; divers swim down the transect line and collect or record all litter items found within 2 m on both sides of the line. Litter is then recorded in terms of either the count of items or the weight per unit of length (e.g. kg / km).

Small litter items should be collected but anything larger should be marked (lead-weighted surface marker buoys can be carried by the divers and released to mark the location of larger items) for possible later removal.

If more than one sampling unit is located within an area then the minimum separation distance should be at least 50 m.

20 sampling units should be allocated within each region (note that a level of redundancy in sampling units within each region is highly recommended).

Sampling frequency

The minimum sampling frequency for any site should be annually. Ideally it is recommended that locations be surveyed every three months (allowing an interpretation of results in terms of seasonal changes). Quarterly sampling is consistent with the recommendations for comprehensive beach litter assessments. Some consideration should be given to tropical regions where there are essentially only two seasons as well as high latitudes where access is likely to be restricted due to extreme remoteness and/or through being iced-in.

Note that previous work under NOWPAP and the Hawaiian surveys was done using annual surveys (Donohue et al. 2001, Timmers et al. 2005, NOWPAP 2007a).

Litter categories and measurement

All litter should be classified using the standard list (Data sheet BL03). Litter items should be counted unless the material is being collected in which case counts and weights may be obtained.

Data sheets

Three data sheets have been developed:

1. Site characterization data sheet (BL01 – single sided) is used to record information about the site at which the visual transect has been run. This sheet records information on the nature of the benthic habitat and the proximity to likely litter sources. The sheet should be filled out only once for each location.
2. Litter characterization data sheet (BL03 – double sided) is used to record survey specific data including categorization and measurement of litter. This is the basic datasheet to be filled in for every survey at each site. If multiple transects are run at any given site then a new sheet should be used for each transect.
3. Large items data sheet (ML01 – single sided) is used to record data on litter items that cannot be removed. This sheet needs to be used for all items to ensure that such items are only counted once (i.e. for the survey during which they are first encountered). Before undertaking a re –survey of any site divers should familiarise themselves with items on this list and ideally note them before commencing the dive.

Data management platform

Data collation should be undertaken through an online, relational database system under the control and direction of the local managers. Responsibility for review and approval of uploaded data should be undertaken by the regional/country coordinator who will clarify any issues with local managers. This would ensure a high level of consistency within each region as well as create a hierarchy of quality assurance on data acquisition.

Equipment needs

Safety is a priority and therefore the use of licensed dive operators to undertake surveys, or alternatively to provide logistic support to field teams, is highly recommended.

All field teams need to be equipped with a comprehensive first-aid kit. For diving operations this should include oxygen resuscitation equipment and access to decompression facilities.

Field team members need appropriate clothing and footwear, protective gloves, hats, sunscreen, wet weather gear, water and food. Major risks to personnel include exposure to heat or cold, stick injuries (e.g. hypodermic syringes) and muscle/joint injuries associated with bending and lifting. Remote operations must follow appropriate safety protocols to ensure personal safety for team members.

For all dive operations, equipment should be well maintained and supported by vessels of an appropriate size and capacity. Good quality communications equipment should always be taken on the boat including mobile phones and HF, VHF or UHF marine radio equipment as required.

For laying out transect lines equipment needs include anchored ropes, marker buoys, and tape measures.

Global Positioning Systems (GPS) are highly desirable, particularly in relocating and determining the location of sampling units. The systems available are increasingly affordable and accurate. In the absence of a GPS a digital camera (e.g. mobile phone camera) can be used to provide images to

support relocation of sampling units although only if operations are conducted sufficiently close to shore to identify reference features.

Where litter weights are required spring balances are available with a range of weight ratings up to 50 kg (and possibly higher). These balances can be used in conjunction with a standard 11 L bucket (or similar) to hold material during measurements. Spring balances have the advantage that they do not require electrical power and they are generally accurate enough (to within 10%) for the purposes of litter characterization but they must be frequently replaced as the spring becomes rusted and worn.

General equipment requirements include collection bags, clip-boards, tape measures, stakes and flagging tape all of which are routinely available from most hardware stores.

A pocket calculator may be useful to sum weights that are collected in batches.

A sharp knife or shears is useful for cutting away entangled litter (rope, cable fishing line and nets).

BENTHIC LITTER Site Data Sheet BL01	Organization		Name of the organization responsible for collecting the data
	Surveyor Name		Name of the surveyor (person responsible for filling in this sheet
	Contact		Phone contact for surveyor
Complete **ONCE** at each site	Date		Collection date for this data

SAMPLING AREA

LocationID			Unique code for the location (office use only)
Site name			Name by which the site is commonly known
Region name			Name for the region (office use only)
LME			Name for the LME in which the Site is located (office use only)
Latitude/Longitude corner 1			As nnn.nnnnn degrees NSEW at one corner of the site
Latitude/Longitude corner opp.			As nnn.nnnnn degrees NSEW at the diagonally opposite corner of site
Co-ordinate system			Datum and coordinate system used to record latitude and longitude

SITE CHARACERISTICS

Slope		Slope of the seabed (degrees)
Aspect		Compass direction perpendicular to the slope (degrees)
Prevailing wind		Direction of prevailing wind (degrees)
Depth		Average depth of the site (metres)
Substratum type		Sand, silt, gravel, rock
Substrate uniformity		An indication of the coverage by the predominant substrate type (Percent)
Presence of reefs		Any rock outcrops in sandy bottom
Presence of seagrass		Presence of seagrass beds

SOURCE CHARACTERISTICS – POTENIAL DEBRIS INPUTS

Nearest river name		Name of nearest river (if relevant) – null value means no inputs
Nearest river distance		Distance to the nearest natural input (river or stream) (kilometres)
Nearest river direction		Direction to the nearest river or stream (degrees)
Nearest major fishery		Name of the nearest major fishery (named by type)
Nearest major fishery distance		Distance to the nearest major fishery (kilometres)
Nearest major fishery direction		Direction to the nearest major fishery (degrees)
Nearest town		Name of nearest town
Nearest town distance		Distance to the nearest town (kilometres)
Nearest town direction		Direction to the nearest town (degrees)
Distance to nearest coast		Distance to the closest coastline (kilometres)
Direction to nearest coast		Direction to the closest coastline (degrees)

Notes

BENTHIC LITTER Trawl Litter Data Sheet BL02	Organization		Name of the organization responsible for collecting the data
	Surveyor Name		
	Contact		Phone contact for surveyor
To be completed once for **EACH** trawl	Date		
	LocationID		Unique code for the location (office use only)

VESSEL AND GEAR CHARACTERISTICS

Vessel name			Name of the vessel
Vessel Length and tonnage			Length of the vessel (metres) Gross tonnage of the vessel (tonnes)
Trawl gear/net details			Grapple, net mesh, net dimensions, etc
Gear anchoring point			Stern or beam/height above water
Distance behind vessel			Distance behind vessel the trawl operates (m)
Depth			Maximum depth at the site (m)

TRAWL SHOT DETAILS

Site sub-block (numbered 1-25)			Sub-blocks are numbered from 1-25 starting at the NE corner and running E-W and progressing N-S
Latitude/Longitude start			Recorded as nnn.nnnnn degrees at the start of the sample unit
Latitude/Longitude end			Recorded as nnn.nnnnn degrees at the end of the sample unit
Co-ordinate system			Datum and coordinate system employed
Distance covered			Total distance covered by the trawl shot (m)

OBSERVATION DETAILS

Time start/end			Time over which the survey was undertaken
Current seas			Wave and swell height (metres)
Current wind			Estimate wind speed & direction at sample start (km/hr & degrees)

LITTER DATA

Item code (standard list)	Description	Count (# items)	Weight (kg)	Item code (standard list)	Description	Count (# items)	Weight (kg)

Notes

BENTHIC LITTER Visual Survey – Litter data sheet BL03	Organization		Name of the organization responsible for collecting the data
	Surveyor Name		Name of the surveyor (person responsible for filling in this sheet
	Contact		Phone contact for the surveyor
To be completed for EACH remote observation transect	Region name		Name for the region
	LocationID		Unique code for the location

Sample unit information

Latitude/Longitude start			Recorded as nnn.nnnnn degrees at the start of the sample unit
Latitude/Longitude end			Recorded as nnn.nnnnn degrees at the end of the sample unit
Co-ordinate system			Datum and coordinate system used to record latitude and longitude

OBSERVATION DETAILS

Sample date			Date sampling was started for the sample
Time start/end			Time over which the survey was undertaken (hh:mm am/pm)
Length of transect			Total distance covered by the transect (m)
Season			Spring, Summer, Autumn, Winter
Sea condition			Wave and swell height (m)
Wind speed and direction			Estimate wind speed & direction at sample start (km/hr & degrees)
Tidal state			Spring, Middle, Neap
Period since last storm			Number of days

LITTER DATA

Item code (standard list)	Description	Count (# items)	Weight (kg)	Item code (standard list)	Description	Count (# items)	Weight (kg)

Notes

MARINE LITTER **Large Items Data Sheet** **ML01**	Organization		Name of the organization responsible for collecting the data
	Surveyor Name		Name of the surveyor (person responsible for filling in this sheet
	Contact		Phone contact for surveyor
Use only for items that were not collected. Complete survey data at top of form and then ONE row for EACH ITEM. Use additional forms if required.	Date		Collection date for this data
	Region name		Name for the region
	LocationID		Unique code for the location
	Coordinate system		Used for all GPS data on this page – provide datum and format

LARGE ITEM DESCRIPTION

Item type (If possible use standard codes)	Status (floating, sunken, stranded, buried)	Latitude (nnn.nnnnn NS)	Longitude (nnn.nnnnn EW)	Description

Chapter IV. Operational Guidelines for Floating Litter Assessment

Objectives for floating litter assessments

Floating litter can be found in all oceans of the world where it threatens marine life and marine ecosystems as well as presenting risks to fishing and maritime transport industries. Floating litter can comprise anything from cigarette butts and plastic bags (that present ingestion risks to marine animals) to discarded or lost fishing nets (that may continue to entangle and kill animals for a prolonged period of time) through to large objects like shipping containers that may present navigation hazards to vessels. Floating litter has also been implicated in providing a vector for the translocation of alien (invasive) species[15].

In this chapter guidelines are presented for comprehensive assessments of floating litter which have the following primary objectives.

1. Quantification and characterization of marine litter for the purposes of developing and evaluating the effectiveness of management, control, enforcement and/or mitigation strategies in particular integration with solid waste management.
2. Understanding the level of threat posed by marine litter to biota and ecosystems.
3. Providing comparable datasets to support national, regional and global assessments of marine litter.

Almost all litter that moves around the oceans floats[16] and therefore a significant proportion of the litter on almost any beach is likely to have spent some of its time floating in adjacent seas and oceans. An understanding of the dynamics of floating litter is therefore fundamental to developing appropriate strategies to manage marine litter in both a global and local context.

The following guidelines have been developed to provide a basis for such investigations.

Floating litter trawl survey operational guidelines

The methodology for floating litter assessments presented in these guidelines has been developed with reference to the seminal work by Ribic et al. (1992) and the more recent work by Shiomoto and Kameda (2005). We also make direct reference to our recommendations for benthic trawl litter surveys (see Chapter IV, which were derived from NOWPAP 2007a).

Two fundamentally different approaches to floating litter sampling have been developed comprising:

1. Trawl surveys where litter floating at the surface (and in the top couple of metres) is collected; and
2. Remote observation surveys where floating litter is assessed but where no litter is actually collected.

Floating litter assessments need to be planned to ensure that they sit within the context of regional management frameworks (Chapter II) and are delivered consistent with the defined protocols. In turn, these protocols need to include the definition and specification of the survey location, choice of sampling units, methodology for collection, classification and quantification of litter and a process for data integration, analysis and reporting of results.

Floating litter surveys that utilise trawl equipment need to make explicit consideration of the potential environmental impact of the operation particularly as these relate to by-catch. Although there is debate as to the nature and extent of environmental damage caused by trawling operations (Collie et al. 2000), alternative approaches to gathering floating debris should always be considered.

[15] Floating litter provides a surface for the growth of plants and animals which are then distributed by wind and currents around the world's oceans; this presents a real risk to many coastal environments that alien species will be transported from distant locations. The presence of fouling biota on litter can also be used to infer the length of time that a litter item has been in the water (although some materials are less likely to support growth by colonising organisms).

[16] Whereas some litter is transported across the seabed this is unlikely to be mode for long distance transport as most seabed litter is ultimately buried or entangled in seabed structures such as reefs.

Litter collected during trawl operations should be categorised using the standardized litter classification system (Chapter II); for remote visual assessments a simplified list is recommended (Chapter II).

Given the nature of the equipment and technical expertise involved, it may be assumed that trawl surveys will not make extensive use of volunteers.

Regional considerations

The sampling design for floating litter should be aligned with the regional framework developed above (Chapter II). At least 20 sampling units will be selected within each region although a higher level of redundancy (i.e. replication) in sampling units within each region is highly recommended.

Data from replicates should be aggregated at the site level, and standardized by area surveyed, before any analysis that attempts to elucidate regional patterns.

Trawl site selection and characterization

Sites should be selected to ensure that:

- There is a focus on areas that are known to generate/accumulate marine litter;
- There is no incidental impact on any endangered or protected species such as sea turtles, sea/shore birds or marine mammals.

Within the above constraints on site selection, sampling units should be stratified relative to sources within a region such that samples are obtained from:

- Urban coasts (i.e. mostly terrestrial inputs).
- Rural coasts (i.e. mostly oceanic inputs).
- Within close distance to major riverine inputs.
- Offshore areas (major currents, shipping lanes, fisheries areas, etc.).

Sampling units

A sampling unit will comprise a fixed 5 km × 5 km survey area (Figure 10). This area should be divided into twenty five sub-blocks of 1 km × 1 km. To ensure an unbiased sample a group of 3 sub-blocks should be randomly selected for trawling.

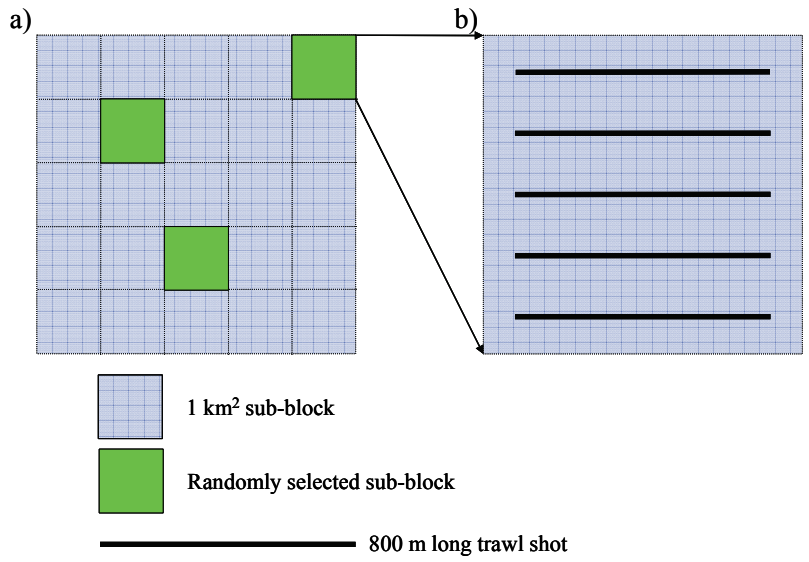


Figure 10. a) Layout of floating trawl samples comprising 3 randomly chosen 1 km × 1km sub-blocks from a 5 km × 5 km sampling unit; b) 1 km × 1 km sub-block showing location of 5 trawl shots.

Trawl sub-samples

Once the three sub-blocks have been selected each can then be trawled. Trawl operations should be conducted such that:

- Ship speed should be restricted to 3-4 knots;
- Each sub-block should be trawled using five parallel trawl shots up to 800 m long;
- Trawl shots should be separated by a minimum of 200 m.
- The ship should proceed in a straight line against the current, so that trawl net is positioned in a line astern.

Data on all litter collected should be aggregated (summed) across all trawl shots and across all 3 sub-blocks. Data should be reported per unit length trawled (e.g. assuming shots of 800 m length and a total of five shots in each of the three sub-blocks this will equate to a total trawl length of 15 × 800 m or 12 km). The width of the trawl net (when set) needs to be incorporated to provide a measurement of area of sea surface trawled (distance in metres multiplied by width of trawl net) and the data will then be reported as kg of litter per square metre of sea surface.

Sampling frequency

Floating litter surveys should be conducted at least annually. Given that the opportunity exists for floating litter surveys to be conducted in close geographical proximity (e.g. offshore) to beach survey sites, then the survey may be conducted at the same time as one or more of the beach surveys. This will then provide an opportunity for an analysis of the relationship between floating litter loads and the flux of litter onto beaches.

Litter categories and measurement

Trawled litter should be classified using the standard categories (see data sheets below) and quantified using weights or number of items as appropriate.

All litter that is collected should be disposed of appropriately.

Data sheets

Three data sheets have been developed in line with the above:

1. Site characterization data sheet (FL01 – single sided) is used to record information about the general area of the 5 km × 5 km survey location. This sheet records information on the nature of the benthic habitat and the proximity to likely litter sources. The sheet should be filled out only once for each location.
2. Trawl litter data sheet (FL02 – single sided) is used to record survey specific data including categorization and measurement of litter collected in the trawl. This is the basic datasheet to be filled in for every trawl shot at each site. If multiple trawl shots are run at any given site then a new sheet should be used for each shot.
3. Large items data sheet (ML01 – single sided) is used to record data on litter items that cannot be removed. This sheet needs to be used for all items. In general for floating litter surveys, this would include items such as shipping containers that are too large to bring on-board. Unlike for beach or benthic litter surveys where large items are likely to be fixed in position, it is unlikely that the same item will be encountered on a repeat survey because floating items are highly mobile.

Data management platform

Data collation should be undertaken through an online, relational database system[17] under the control and direction of the local managers. Responsibility for review and approval of uploaded data should be undertaken by the regional/country coordinator who will clarify any issues with local managers. This would ensure a high level of consistency within each region as well as create a hierarchy of quality assurance on data acquisition.

Equipment needs

Equipment needs and operational logistics for trawl surveys are extensive and highly specialised (see e.g. NOWPAP 2007a and related references). For surface trawls these are the general requirements:

- Configuration of trawl equipment will be dependant on the type of floating litter and geographical conditions; typically nets may be 2-4 cm mesh size and up to 6 m wide;
- Rope length has to be determined depending on the size of the trawl net and net spread, specialist advice on setting a trawl should be obtained;
- Floating litter should be taken on board with proper equipment such as side rollers;
- Litter can be sorted directly on board provided deck space is available, care should be taken to ensure safety of personnel through use of protective clothing including gloves;
- After collection and sorting, facilities are required to safely count and weigh litter; specialist lifting and weighing equipment may be required.

Floating litter visual survey operational guidelines

Floating litter can be observed either from vessels or aircraft (Ribic et al. 1992). Regardless of the platform being used, regional considerations, sampling units and litter characterization should be the same. However, unlike other surveys, floating litter observations do not necessarily need to occur as a stand alone activity and can be incorporated as a component of other sea-going operations (using “Ships of Opportunity”) such as those related to fisheries, transport, defence or other research. While this may limit observations in some respects, there are also advantages in terms of costs relative to a dedicated survey as well as the opportunity to target litter loads along major shipping lanes and fishery zones.

[17] The detailed design of an appropriately configured RDBS is beyond the scope of this project but it should be noted that the NMDMP, OSPAR and AMDS programmes all have databases that have been designed or developed and any of which should be suitable with a modest level of customization. The key thing would be to ensure that litter classification (see below) and beach characterization data structures were appropriately modified to address the flexibility issues required of this system.

Regional considerations

A geographical hierarchy for sampling may be aligned with that used for beach surveys although the opportunity presented in the *ad-hoc* use of ocean going vessels should not be ignored.

Visual survey site selection and characterization

Visual survey sites are best chosen in areas that:

- Focus on areas that are known to generate or accumulate (convergence zones) marine litter such as major shipping lanes, or areas with concentrated fisheries or similar commercial activities.
- Will not impact on endangered or protected species such as sea turtles, sea/shore birds or marine mammals; although given that visual surveys are generally low impact, relative to benthic or surface trawls, there is generally less scope for impacts.

Within the above constraints on site selection, sampling units should be stratified relative to sources within a region such that there are samples obtained from:

- Urban coasts (i.e. mostly terrestrial inputs);
- Rural coasts (i.e. mostly oceanic inputs);
- Within close distance to major riverine inputs;
- Offshore areas (major currents, shipping lanes, fisheries areas, etc.).

Sampling units

The basic sampling unit for a visual survey will comprise a transect represented by an imaginary line over the surface of the ocean which is either travelled by a vessel or aircraft. The line does not need to be straight although it is easier if it is. The observer will record all litter within a fixed distance on one or both sides of the line (see below). The width of the field of view should be recorded along with data about the distance travelled and the litter observed.

Visual Transects should be established by monitoring the time employed by observers rather than attempting to identify fixed length units. Ideally location should be mapped using route plotters connected to on-board GPS systems that can record changes in vessel direction and therefore can be used to quantify the size and geographical location of the area surveyed. This approach assumes there will be differences in vessel speed and changes in direction that are beyond the control of the litter observers.

Limiting observations to a fixed time period (typically two hours) will help avoid apathy and fatigue while at the same time allow large areas to be surveyed (even at slow speed).

Transects of varying length are consistent with the methods employed by Shiomoto and Kameda (2005) in their floating litter survey around Japan.

Litter should be measured as per the methods outlined in Ribic et al. (1992) and employed in Shiomoto and Kameda (2005) for strip transects, wherein all litter are recorded within a fixed distance of the direction of travel by the vessel (typically a distance of 50 or 100 m either or both sides of the vessel). The decision about whether to survey both sides of the vessel depends on sea-state, and the field of view of the observer which may differ between vessels.

A minimum distance between transects of 1 km should prevent overlap.

At least 20 sampling units should be randomly allocated within each region (note the stratification recommended above and that a level of redundancy in sampling units within each region is highly recommended).

Sampling frequency

The minimum sampling frequency for any site should be annually. Ideally it is recommended that locations be surveyed every three months (allowing an interpretation of results in terms of seasonal changes). Quarterly sampling is consistent with the recommendations for comprehensive beach litter assessments. Some consideration should be given to tropical regions where there are essentially only

two seasons as well as high latitudes where access is likely to be restricted due to extreme remoteness and/or through being iced-in.

Ribic et al. (1992) do not specify a recommended survey frequency and the Shiomoto and Kameda (2005) survey was a one-time operation.

Floating litter surveys may be more opportunistic in terms of sampling interval, although the development of engagements with shipping organizations may support more regular observations, particularly along major shipping routes.

Litter categories and measurement

Litter categorization is generally much more difficult for remote observations. Observers are not able to "interact" with individual litter items so a simplified list of items has been developed (Chapter II).

Data sheets

Two data sheets have been developed in line with the above:

1. Site characterization data sheet (FL01 – single sided) is used to record information about the survey location. This sheet records information about the proximity of the site to likely litter sources. The sheet should be filled out only once for each survey.
2. Visual observation data sheet (FL03 – single sided) is used to record survey specific data including categorization and measurement of litter observed. This is the basic datasheet to be filled in for every transect at each site. If multiple transects are run at any given site then a new sheet should be used for each shot. If multiple observers are recording data with different fields of view (e.g. one person observing to the starboard side and the other person observing to port) then each person should fill out a separate copy of this sheet. Data should be aggregated for analysis and reporting.

Data management platform

Data collation should be undertaken through an online, relational database system[18] under the control and direction of the local managers. Responsibility for review and approval of uploaded data should be undertaken by the regional/country coordinator who will clarify any issues with local managers. This would ensure a high level of consistency within each region as well as create a hierarchy of quality assurance on data acquisition.

Equipment needs

Equipment needs for the remote observation of floating litter need not be onerous if regular access can be obtained to appropriate vessels travelling regular routes. GPS units that are used to record the survey path (transect) will need to have a tracking function and binoculars will improve the capacity to identify litter items.

[18] The detailed design of an appropriately configured RDBS is beyond the scope of this project but it should be noted that the NMDMP, OSPAR and AMDS programmes all have databases that have been designed or developed and any of which should be suitable with a modest level of customization. The key thing would be to ensure that litter classification (see below) and beach characterization data structures were appropriately modified to address the flexibility issues required of this system.

FLOATING LITTER ASSESSMENT – SITE CHARACTERIZATION DATA SHEET

FLOATING LITTER Site Data Sheet FL01	Organization		Name of the organization responsible for collecting the data
	Surveyor Name		Name of the surveyor (person responsible for filling in this sheet
	Contact		Phone contact for surveyor
Complete **ONCE** at each site	Date		Collection date for this data

SAMPLING AREA

LocationID			Unique code for the location (office use only)
Site name			Name by which the site is commonly known
Region name			Name for the region (office use only)
LME			Name for the LME in which the Site is located (office use only)
Latitude/Longitude corner 1			As nnn.nnnnn degrees NSEW at one corner of the site
Latitude/Longitude corner opp.			As nnn.nnnnn degrees NSEW at the diagonally opposite corner of site
Co-ordinate system			Datum and coordinate system used to record latitude and longitude

SITE CHARACERISTICS

Prevailing wind		Direction of prevailing wind (degrees)
Depth		Average depth of the site (metres)

SOURCE CHARACTERISTICS – POTENIAL DEBRIS INPUTS

Nearest river name		Name of nearest river (if relevant) – null value means no inputs
Nearest river distance		Distance to the nearest natural input (river or stream) (kilometres)
Nearest river direction		Direction to the nearest river or stream (degrees)
Nearest major fishery		Name of the nearest major fishery (named by type)
Nearest major fishery distance		Distance to the nearest major fishery (kilometres)
Nearest major fishery direction		Direction to the nearest major fishery (degrees)
Nearest town		Name of nearest town
Nearest town distance		Distance to the nearest town (kilometres)
Nearest town direction		Direction to the nearest town (degrees)
Distance to nearest coast		Distance to the closest coastline (kilometres)
Direction to nearest coast		Direction to the closest coastline (degrees)

Notes

FLOATING LITTER Trawl Litter Data Sheet FL02	Organization		Name of the organization responsible for collecting the data
	Surveyor Name		
	Contact		Phone contact for surveyor
To be completed once for **EACH** trawl	Date		
	LocationID		Unique code for the location (office use only)

VESSEL AND GEAR CHARACTERISTICS

Vessel name			Name of the vessel
Vessel Length and tonnage			Length of the vessel (metres) Gross tonnage of the vessel (tonnes)
Trawl gear/net details			Grapple, net mesh, net dimensions, etc
Gear anchoring point			Stern or beam/height above water
Distance behind vessel			Distance behind vessel the trawl operates (m)
Depth			Maximum depth at the site (m)

TRAWL SHOT DETAILS

Site sub-block (numbered 1-25)			Sub-blocks are numbered from 1-25 starting at the NE corner and running E-W and progressing N-S
Latitude/Longitude start			Recorded as nnn.nnnnn degrees at the start of the sample unit
Latitude/Longitude end			Recorded as nnn.nnnnn degrees at the end of the sample unit
Co-ordinate system			Datum and coordinate system employed
Distance covered			Total distance covered by the trawl shot (m)

OBSERVATION DETAILS

Time start/end			Time over which the survey was undertaken
Current seas			Wave and swell height (metres)
Current wind			Estimate wind speed & direction at sample start (km/hr & degrees)

LITTER DATA (continues over page)

Item code (standard	Description	Count (# items)	Weight (kg)	Item code (standard list)	Description	Count (# items)	Weight (kg)

LITTER DATA continued …

Item code (standard	Description	Count (# items)	Weight (kg)	Item code (standard list)	Description	Count (# items)	Weight (kg)

Notes

FLOATING LITTER Visual Observation Data Sheet FL03	Organization		Name of the organization responsible for collecting the data
	Surveyor Name		Name of the surveyor (person responsible for filling in this sheet
	Contact		Phone contact for surveyor
To be completed once for **EACH** trawl	Date		Collection date for this data
	LocationID		Unique code for the location (office use only)

VESSEL AND GEAR CHARACTERISTICS

Vessel name			Name of the vessel (or plane registration)
Vessel length and tonnage			Length of the vessel (metres) Gross tonnage of the vessel (tonnes)
Depth			Maximum depth at the site (m)

VISUAL SURVEY TRANSECT DETAILS

Latitude/Longitude start			Recorded as nnn.nnnnn degrees at the start of the sample unit
Latitude/Longitude end			Recorded as nnn.nnnnn degrees at the end of the sample unit
Width of assessment			Total width of transect (including both sides of transect line) (m)
Co-ordinate system			Datum and coordinate system employed
Distance covered			Total distance covered by the trawl shot (m)

OBSERVATION DETAILS

Time start/end			Time over which the survey was undertaken
Current seas			Wave and swell height (metres)
Current wind			Estimate wind speed & direction at sample start (km/hr & degrees)

LITTER DATA (continues over page)

Item code (standard list)	Description	Count (# items)	Item code (standard list)	Description	Count (# items)

LITTER DATA continued …

Item code (standard list)	Description	Count (# items)	Item code (standard list)	Description	Count (# items)

Notes

FLOATING LITTER ASSESSMENT – LARGE ITEMS DATA SHEET

MARINE LITTER **Large Items Data Sheet** **ML01**	Organization		Name of the organization responsible for collecting the data
	Surveyor Name		Name of the surveyor (person responsible for filling in this sheet
	Contact		Phone contact for surveyor
Use only for items that were not collected. Complete survey data at top of form and then ONE row for EACH ITEM. Use additional forms if required.	Date		Collection date for this data
	Region name		Name for the region
	LocationID		Unique code for the location
	Coordinate system		Used for all GPS data on this page – provide datum and format

LARGE ITEM DESCRIPTION

Item type (If possible use standard codes)	Status (floating, sunken, stranded, buried)	Latitude (nnn.nnnnn NS)	Longitude (nnn.nnnnn EW)	Description

Chapter V. Operational Guidelines for Rapid Beach Litter Assessment

Objectives for rapid beach litter assessments

Beach surveys have long been the primary tool for measuring the load of marine litter in coastal and marine systems and they also provide an invaluable mechanism for education and building community understanding.

Historically surveys of marine litter accumulation on beaches have been the most commonly used method for estimating loads in the sea (e.g. Ribic *et al.* 1992, ANZECC 1996a, b, Rees and Pond 1998, Kiessling 2003, Stuart 2003), however, there has been a marked lack of consistency in sampling protocols and litter characterization (classification).

In this chapter guidelines are presented for rapid assessments of beach cast litter which have the following primary objectives.

1. Quantification, characterization and identification of sources of marine litter for the purposes of developing and evaluating the effectiveness of management, control, enforcement and/or mitigation strategies in particular integration with solid waste management.
2. Understanding the level of threat posed by marine litter to biota and ecosystems.
3. Providing comparable datasets for national and regional assessments of marine litter.
4. Creation and strengthening of public awareness of marine litter issues through community engagement.

In developing these objectives it needs to be recognized that such guidelines should be able to address a number of basic questions about marine litter relating to the management, mitigation, sources and risks associated with litter in the environment (Table 5). In turn, such questions allow evaluation of the information collected from monitoring programmes and thereby assess its utility in supporting management responses.

Table 5 . Key questions to be addressed through rapid assessment of beach litter.

Monitoring Questions	Monitoring Parameters
Are management/mitigation strategies effective?	Litter Quantity (counts/weight) – changes through time.
What are the sources and activities leading to production of marine litter?	Litter categories (indicator items)
Is there a threat to marine biota and ecosystems?	Litter categories (indicator items)

Rapid beach litter assessments provide a tool that can be applied by a wide variety of groups including community organizations, schools, indigenous communities and commercial enterprises. The protocols have been designed as stand-alone assessments and therefore they do not make prescriptions about how individual surveys should fit in relation to broader regional frameworks, the size and spatial configuration of sampling units, the sampling frequency or quality control procedures.

Rapid assessments can contribute to a number of objectives in marine litter management including:

- Quantification, characterization and identification of sources of marine litter for the purposes of developing and evaluating the effectiveness of management, control, enforcement and/or mitigation strategies in particular integration with solid waste management.
- Understanding the level of threat posed by marine litter to biota and ecosystems.
- Providing comparable datasets for national assessments of marine litter.

- Creation and strengthening of public awareness of marine litter issues through community engagement.

- Building capacity in marine litter assessment that underpins the transition to a comprehensive assessment framework.

Beach litter rapid survey operational guidelines

The rapid assessment guidelines have been developed from the comprehensive guidelines in Chapter III. Fewer prescriptions are made about sampling frameworks and the concomitant linkages to national or regional programmes. Similarly, the assessment is not intended for application where detailed information about litter fluxes is required.

Rapid litter assessments should focus at the local scale although data may be aggregated or contributed into state, province or country scale assessments. The key element in developing rapid beach litter assessments is in selecting beaches which are accessible to survey teams.

Beach selection and characterization

When undertaking rapid beach litter assessments there is a need to identify and select suitable beaches to allow the establishment of appropriate sampling units.

Beach selection criteria should include:

- A minimum length of 100 m (i.e. sufficient to fit the smallest sampling unit) although beaches with small amounts of litter may need to be longer (e.g. 1 km);

- Low to moderate slope (15 – 45º), which precludes very shallow tidal mudflat areas that may be many kilometres wide at low tide;

- Clear access to the sea (not blocked by breakwaters or jetties) such that marine litter is not screened by anthropogenic structures;

- Accessible to survey team members all year round, although some consideration needs to be given to sites that are iced-in over winter and the difficulty in accessing very remote areas;

- Survey activities should not be undertaken where there is risk of impact on any endangered or protected species such as sea turtles, sea birds or shore birds, marine mammals or sensitive beach vegetation; in many cases this would exclude national parks but this may vary depending on local management arrangements.

Each survey location will require a team leader who is able to liaise with relevant local area managers (e.g. local government representatives, park rangers, etc). The team leader will also be responsible for recruiting survey volunteers and organising field operations for each survey.

At each location data need to be collected relating to the nature of the beach environment including:

Total beach length.

Total beach width at low tide (provides an estimate of beach slope)

Nearest river – name, distance, direction and whether or not it inputs directly to the beach.

Nearest town – name, distance and direction.

- Main beach usage (i.e. recreational – swimming and sunbathing, fishing, surfing, boat access or remote).

- Access (vehicular, pedestrian and/or boat only).

Tidal range should be obtained from published tidal data.

The back of the beach should be described in terms of the dominant features, be it dunes, vegetation or built structures (rock walls, road, path, fence, etc).

- Any other noteworthy information (e.g. an otherwise remote and unvisited location may be subject to an annual surfing competition that results in a “pulse” of litter).

This information only needs to be collated once for each site and it may then be used for all future surveys. Much of this information can be obtained from maps and similar sources (e.g. Google Earth™ images), although such information should always be checked by direct observation at the site.

Additional information (see Comprehensive Beach Litter Assessments – Chapter III) may be collected particularly if the intention is to use the rapid assessment as a springboard for developing survey teams who may later participate within a comprehensive research programme.

Sampling units

Rapid litter assessments can be conducted over any length of beach although a minimum survey length of 100 m is recommended. Sampling may thus vary substantially between surveys in terms of the area considered and sampling effort applied.

The length of beach surveyed and the width of the beach should be recorded such that litter quantities can be standardized to kilograms or counts of items per unit length of beach.

Sampling frequency

The minimum sampling frequency for any one site should be at least annually. Ideally sampling should be conducted once every three months to obtain a good comparison of seasonal changes.

One off surveys may be undertaken, and the data will be useful in developing training and awareness programmes.

Laying out a typical survey

Depending on the number of survey team members, the survey process can be undertaken in either of two ways (consistent with the NMDMP protocol; Sheavly 2007). Surveyors form skirmish lines either at right angles to the coast (2-5 persons) or parallel to the coast (>5 persons). In both cases there should be around 2 m between persons forming the line.

All litter within the sampling unit larger than 2.5 cm in longest linear dimension should be collected. Upon completion of collection, the litter must be sorted and measured according to the categories in Appendix C.

Assessment of small items, such as cigarette butts should be considered at the discretion of the survey organisers, although sampling within 10 m wide sub-units as per the comprehensive survey may also be considered.

Large immoveable objects (abandoned cars, very large nets, baulks of timber, etc) that cannot be moved by the team members should be recorded on an additional datasheet, with information collected on the nature and location (preferably GPS fixed) for each large item. This information will be submitted along with the other datasheets to ensure that any large item is included only once in analysis. In addition, the item may be marked (preferably with paint), to indicate the item has been included (Wennecker pers. comm.).

Data sheets

Three data sheets have been developed for rapid beach litter assessments including:

1. Site characterization data sheet (BR01 – double sided) is used to record information on the characteristics of the beach and proximity to local litter sources. This sheet only needs to be filled out once for each beach.
2. Litter characterization data sheet (BR02 – double sided) is used to record survey specific data including categorization and measurement of litter. This is the basic datasheet to be filled in for every survey at each site.
3. Large items data sheet (ML01 – single sided) is used to record data on litter items that cannot be removed. This sheet needs to be used for all such items to ensure that they are only counted once (i.e. for the survey during which they are first encountered even if this is the initial clearance survey). Subsequent surveys should be based on a review of previously collected data and ideally a summary of this information should be taken into the field to ensure that these items are not recounted.

Litter characterization

Litter characterization should use the same approach as the comprehensive surveys.

All collected litter should be disposed of appropriately.

Data management platform

Data may be contributed to regional coordinators where a team is working to develop capacity for the delivery of comprehensive beach surveys. Otherwise, the data should be summarised by litter type and reported in terms of the amount of litter per unit length of beach.

Equipment needs

Safety is a priority and all field teams need to be equipped with a comprehensive first-aid kit. Field team members need appropriate clothing and footwear, protective gloves, hats, sunscreen, wet weather gear, water and food. Major risks to personnel include exposure to heat or cold, stick injuries (e.g. hypodermic syringes) and muscle/joint injuries associated with bending and lifting. Remote operations must follow appropriate safety protocols to ensure personal safety for team members.

Global Positioning Systems (GPS) are highly desirable, particularly in relocating and determining the length of sampling units. The systems available are increasingly affordable and accurate. In the absence of a GPS a digital camera (e.g. mobile phone camera) can be used to provide photographs of key reference features on the beach to support relocation of sampling units.

Where litter weights are recorded, battery powered electronic balances with an operating range of 0-10 kg are now routinely available and ideal for weighing smaller collections of items. Spring balances are available with a range of weight ratings up to 50 kg (and possibly higher). These balances can be used in conjunction with a standard 11 L bucket (or similar) to hold material during measurements. Spring balances have the advantage that they do not require electrical power and they are generally accurate enough (to within 10%) for the purposes of litter characterization but they must be frequently replaced as the spring becomes rusted and worn.

General equipment requirements include collection bags, clip-boards, tape measures, stakes and flagging tape all of which are routinely available from most hardware stores.

A pocket calculator may be useful to sum weights that are collected in batches.

A sharp knife or shears is useful for cutting away entangled litter (rope, cable fishing line and nets).

Access to remote areas cannot be achieved without appropriate (generally 4WD) vehicles. They have the added advantage that heavy items can often be loaded into the tray (particularly if they come equipped with lifting gear) or alternatively dragged to a collection point.

BEACH LITTER Beach Data Sheet BR01	Organization		Name of the organization responsible for collecting the data
	Surveyor Name		Name of the surveyor (person responsible for filling in this sheet
	Phone number		Phone contact for surveyor
Completed **ONCE** for each site	Date		Date of this update to the data

SAMPLING AREA

BeachID		Unique identity code for the beach (office use only)
Beach name		Name by which the beach is commonly known
Region name		Name for the region (office use only)
LME		Name for the LME in which the Beach is located (office use only)
Co-ordinate system		Datum and coordinate system used to record latitude and longitude

BEACH CHARACTERISTICS – considered from the start point of the transect

Total beach length		Length measured along the mid point of the beach (kilometres)
Substratum type		Defines whether predominantly a sandy or gravel beach (pebble, rock etc)
Substrate Uniformity		An indication of the coverage by the predominant substrate type (Percent)
Tidal range		Max – min vertical tidal range (metres)
Tidal distance		Horizontal distance (metres) from the lowest tide to back of the beach
Back of beach		Describe the landward limit (Rock wall, Cliff, Dune, Anthropogenic)

SOURCE CHARACTERISTICS – considered from the start point of the transect

Location & major beach usage	URBAN		Select one & indicate the major usage type (swimming and sunbathing, fishing, surfing, boat access or remote).
	PERI-URBAN		
	RURAL		
Access			Vehicular (can drive on beach), pedestrian (must walk), isolated (i.e. need a vessel)
Nearest town			Name of nearest town
Nearest town distance			Distance to the nearest town (kilometres)
Nearest town direction			Direction to the nearest town (degrees)
Nearest river name			Name of nearest river (if relevant) – a null value is assumed to mean no inputs to this location
Nearest river distance			Distance to the nearest river (or stream) (kilometres)
Nearest river direction			Direction to the nearest river or stream (degrees)
River/creek input to beach	YES	NO	Whether the nearest river or stream has an outlet directly to this beach (yes/no)
Pipes or drains input	YES	NO	Distance and direction probably (yes/no)

Other notes

BEACH LITTER **Sample AND Beach litter data** **BR02** Completed **ONCE** for each beach and for each survey	Organization		Organization responsible for the survey
	Surveyor Name		Name of the surveyor (person responsible for filling in this sheet)
	Contact		Phone contact for surveyor
	Region		Name for the region
	BeachID		Unique identity code for the beach (office use only)

Sample unit information

Beach Name			Unique Name by which the beach is known
Latitude/longitude start			Recorded as nnn.nnnnn degrees at the start of the sample – indicate NSEW
Latitude/longitude end			Recorded as nnn.nnnnn degrees at the end of the sample – indicate NSEW
Coordinate system			Datum and coordinate system for latitude and longitude
Sample date			Date sampling was started for the sample (generally today's date)
Time start/end			Time taken to complete the survey (h)
Season			Spring, Summer, Autumn, Winter, NE Monsoon etc
Date of last survey			Date on which the beach was last cleaned either by survey or maintenance clean up
Storm activity			Has there been any significant storm activity since the last survey
Number of persons			Number of persons collecting litter
Length of beach being surveyed			Length of sample unit along the beach (m)
Width of beach			Width of beach at the time of survey (m)
Large items			Add each new item on the sheet provided

LITTER DATA (continue over page if more space required)

Item code (standard	Description	Count (# items)	Weight (kg)	Item code (standard list)	Description	Count (# items)	Weight (kg)

Notes

LITTER DATA continued …

Item code (standard list)	Description	Count (# items)	Weight (kg)	Item code (standard list)	Description	Count (# items)	Weight (kg)

Notes

<table>
<tr><td rowspan="3">Marine LITTER
Large Items Data Sheet
ML01</td><td>Organization</td><td></td><td>Name of the organization responsible for collecting the data</td></tr>
<tr><td>Surveyor Name</td><td></td><td>Name of the surveyor (person responsible for filling in this sheet</td></tr>
<tr><td>Contact</td><td></td><td>Phone contact for surveyor</td></tr>
<tr><td rowspan="5">Use only for items that were not collected.
Complete survey data at top of form and then ONE row for EACH ITEM.

Use additional forms if required.</td><td>Date</td><td></td><td>Collection date for this data</td></tr>
<tr><td>Region name</td><td></td><td>Name for the region</td></tr>
<tr><td>LocationID</td><td></td><td>Unique code for the location</td></tr>
<tr><td>Coordinate system</td><td></td><td>Used for all GPS data on this page – provide datum and format</td></tr>
</table>

LARGE ITEM DESCRIPTION

Item type (If possible use standard codes)	Status (floating, sunken, stranded, buried)	Latitude (nnn.nnnnn NS)	Longitude (nnn.nnnnn EW)	Description

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Appendix A. UNEP/IOC Technical Working Group members

The following persons participated as members of the Technical Working Group and contributed to the development of this document.

Table 6. TWG members

Region/Nominating Organization	Name	Affiliation
Australia (Government of Australia)	Prof. Anthony Cheshire	TWG Team Leader / Science to Manage Uncertainty
USA (Ocean Conservancy)	Dr. Seba Sheavly	Ocean Conservancy / SHEAVLY Consultants
North-East Atlantic (OSPAR)	Dr. Barbara Wenneker (The Netherlands)	North Sea Directorate, Ministry of Transport, Public Works and Water Management
	Dr. Lex Oosterbaan (The Netherlands)	North Sea Directorate, Ministry of Transport, Public Works and Water Management
	Dr. Susan Kinsey (United Kingdom)	Marine Conservation Society, closely affiliated to Seas at Risk (an official Observer Organization of OSPAR)
Baltic Sea (HELCOM)	Dr. Sverker Evans (Sweden)	Swedish Environmental Protection Agency, Environmental Assessment Department
Northwest Pacific (NOWPAP)	Dr. Alexander Tkalin	Northwest Pacific Action Plan, Regional Coordinating Unit
	Dr. Jung Rho-Taek (Korea)	Dept. of Ocean System Technology, Korea Ocean Research and Development Institute (KORDI/MOERI)
	Dr. Eng Takashi Kusui (Japan)	Department of Environmental Systems Engineering, College of Technology, Toyama Prefectural University
Eastern Africa (Nairobi Convention / WIO-LAB)	Mr. Marcos A. Pereira (Mozambique)	Association for the Study of Coast and Marine (AICM), Mozambique
Caribbean/Latin America (CAR/RCU)	Ms. Ingrid Lavine (Barbados)	Environmental Protection Department, Barbados
Mediterranean (MAP)	Prof. Yuval Cohen (Israel)	University of Haifa & Environmental Consulting
East Asian Seas (COBSEA)	Dr. Srisuda Jarayabhand (Thailand)	East Asian Seas, Regional Coordinating Unit
South Asian Seas (SACEP/SAS)	Dr. Sampath Varadarajan (India)	SACEP/SAS Regional consultant / Ex-Advisor, Ministry of Earth Sciences, Government of India (Retired)
IOC of UNESCO	Mr. Julian Barbière	Intergovernmental Oceanographic Commission of UNESCO, Ocean Sciences Section
UNEP	Dr. Ellik Adler	Regional Seas Programme Coordinator
	Dr. Ljubomir Jeftic	Regional Seas Marine Litter Consultant
	Mr. Peter Manyara	Regional Seas Programme

Appendix B. Comparison of existing marine litter survey and monitoring protocols

Thirteen different marine litter survey protocols were considered (Table 7), with each survey reviewed against a set of 46 evaluation criteria (Table 9), which provided the basis for comparing the various survey protocols. The criteria employed were abstracted from the literature and selected to target a set of best practice approaches for marine litter surveys (see Ribic et al. 1992 for a seminal discussion on developing protocols). These criteria were critiqued by the UNEP/IOC Marine Litter Technical Working Group (TWG) and through a consideration of relevant marine litter reviews (Rees and Pond 1995, ANZECC 1996a, Kiessling 2003, Stuart 2003, Sheavly 2007, Cheshire and Westphalen 2007). The criteria were mostly configured to enable simple yes/no questions and covered a range of issues that were broadly grouped firstly into a set of general questions that were relevant to all surveys regardless of type (beach, benthic or floating), including details of:

- Sampling units and sampling frequency
- Litter characterization
- Logistics and facilitation

Table 7. Marine litter survey protocols that were compared in this study.

Survey name	Short name (acronym)	Source reference
Beach surveys		
Australian Marine Debris Survey	AMDS	Cheshire and Westphalen 2007
National Marine Debris Monitoring Program	NMDMP	US Environment Protection Agency 2002, Sheavly 2007
Northwest Pacific Action Plan (NOWPAP) – beach litter survey	NOWPAP – beach	NOWPAP 2007b
Korean Ministry of Maritime Affairs and Fisheries	KMMAF	MOMAF 2002
International Coastal Cleanup (ICC).	ICC	The Ocean Conservancy 2002
Commission for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Commission).	OSPAR – beach	OSPAR 2007
Commission for the Conservation of the Antarctic Marine Living Resource	CCALR – beach	CCAMLR 2008
World Wide Fund for Nature.	WWF	White 2005
Clean Coast Index.	CCI	Alkalay et al. 2007
Floating litter surveys		
Japan	Japan – floating	Shiomoto and Kameda 2005
Floatables Action Plan	FAP	US Environment Protection Agency 2002, 2007
Benthic litter surveys		
Northwest Pacific Action Plan (NOWPAP) – seabed litter survey	NOWPAP – benthic	NOWPAP 2007a
Marine debris in the Northwest Hawaiian Island	NDNHI	Donohue et al. 2001, Timmers et al. 2005

These questions were augmented with a series of additional queries that were developed to elucidate characteristics specific to the different types of surveys and were therefore particular to each of the beach, benthic and floating litter survey protocols (Table 9).

The response to each question is detailed in Table 9 with a summary of each issue provided in the following.

General criteria relevant to all survey types – Survey framework

1 Research, operational or community awareness programmes

Survey design is largely predicated on the objectives and in particular whether the survey is conducted for research purposes, as part of an operational management or cleanup programme or to improve community awareness of marine litter issues.

Nine of the thirteen surveys considered had a significant research focus (includes the AMDS, NOWPAP – Benthic, NOWPAP – Beach, KMMAF, ICC, WWF, CCI and NDNH), of which over half (AMDS, NOWPAP – Benthic, KMMAF, WWF and NDNHI) also encompassed some degree of community awareness as an objective. This focus on the general community recognizes the critical reliance on volunteer support for many beach surveys. Only three of the beach survey protocols (NOWPAP – Beach, ICC and CCI) had no research element.

Similarly, even those surveys that have little capacity to use volunteers (such as benthic, floating and clearance operations such as the NOWPAP – Benthic and FAP) frequently maintain community awareness amongst their objectives. The latter may relate to a need to engage industry partners (e.g. fisheries and/or transport industries) who have a need to generate or maintain a positive public profile.

2 Standing crop or flux rate

There are two basic forms of beach litter assessment:

- Standing crop, which is a “snapshot” of litter at a point in time, this generally entails litter observation but not necessarily litter removal.
- Flux (or accumulation) rate of marine litter over a specific period of time, this requires litter clearance.

Nearly all beach surveys (10 out of 13) consider flux rates rather than standing crop. Exceptions include The Clean Coast Index (CCI) from Israel and the annual ICC events both of which are targeted at standing crop observations and the Shiomoto and Kameda (2005) survey from Japan which assessed floating litter and is also a standing crop assessment.

3 Regionalization/sample representation

Survey protocols varied substantially in terms of the extent to which they provide information about litter deposition at larger spatial scales. Only three surveys, OSPAR, NMDMP and AMDS, consider sites within predefined regions that could be correlated with major currents, coastal features and/or proximity to sources. The NOWPAP Beach and Benthic surveys considered provinces within the member states, but the relationship between these anthropogenic boundaries and the physical environment is unclear. Many surveys appear to consider each site as a stand alone unit with no capacity to aggregate or compare data at higher spatial scales.

Floating litter surveys may be less constrained, operating over 100s – 1000s of kilometres, although floating litter clearance operations such as the FAP are limited to ports, harbours and embayments.

There is a spatial hierarchy of sampling within the NMDMP which divides the US coast into nine regional areas based on oceanographic, meteorological and logistical criteria (Sheavly 2007). Similar designations have been used in the OSPAR surveys (five regions; OSPAR 2007) and have been recommended for litter sampling in Australia (five to ten regions; ANZECC 1996a, Cheshire and Westphalen 2007).

4 Sea conditions during survey

Only the CCAMLR survey collects data on wave height and frequency, while there are only four other surveys (AMDS, NMDMP, KMMAF and CCAMLR) that collect data on wind strength and direction. There is a divergence of opinion with respect to the need for information on conditions at the time of the survey (e.g. Ribic et al. 1992, OSPAR 2006, Cheshire and Westphalen 2007, Sheavly 2007).

Surprisingly, surveys that rely on vessels (NOWPAP-Benthic, FAP, Japan Floating Debris and the NDNHI) do not collect data on sea conditions (although the Japanese survey did collect data on visibility).

It therefore seems arguable that there is a need for substantial data on conditions at the time of survey, particularly with respect to beach surveys, although factors that affect the collectors (extreme heat, cold, snow and/or rain, etc) should be noted.

5 Specialized equipment

For a beach survey, basic equipment might be considered to comprise the datasheets, collection bags and tape measures. While five of the beach surveys can be undertaken without the need for more sophisticated equipment (KMMAF, ICC, CCAMLR, WWF and CCI), most protocols require access to a GPS, and others require weighing scales and, in some instances (WWF in northern Australia), 4WD vehicles and/or heavy lifting equipment.

Specialised equipment needs are substantial for benthic/floating litter surveys (e.g. boats/ships or aerial platforms, diving equipment, dredging equipment, etc).

Ideally, all litter survey protocols should employ sampling units that are GPS referenced. For vessel-based operations this should present little difficulty, although portable GPS units that would be used for beach surveys are increasingly accurate and affordable[19] (Cheshire and Westphalen 2007).

General criteria relevant to all survey types – Sampling units and sampling frequency

6 Sampling units and replication

In marine litter surveys a sampling unit can be defined as a length or area of beach, ocean or seabed. Data about litter loads (types and amounts) are collected from the sampling unit and these data are then used to provide a basis for reporting or comparison (quantitative or statistical analysis).

Beach litter surveys

Most beach litter operations (excluding the NOWPAP – Beach and the ICC) involve the identification of discrete sampling units that vary from 10-1500 m in length. The use of a known length sampling unit allows litter load to be reported (in terms of either weight or count) per unit length of beach (e.g. kg / km of beach as per the AMDS surveys or number of items per 500 m sampling unit as per the NMDMP, Sheavly 2007).

Typically beach surveys vary widely in the length of beach surveyed; this relates both to the area to be covered (related to the width of the beach) but more often relates to the quantity of litter that may accumulate on the beach. Some beaches acquire relatively little litter in which case a larger length or area is required in order to generate a sufficient sample. Other locations may accumulate large amounts of litter such that the sheer volume makes removal and characterization logistically prohibitive except for relatively short lengths of the beach.

A simple approach to estimating the appropriate length of beach to survey is to examine the relationship between the numbers of new types of litter observed for progressively larger sections of beach. This approach is based on the commonly used species x area curves used by ecologists to determine the size of a sampling unit required for vegetation analysis.

The method requires the researcher to successively sample areas of beach starting with (for example) a 10 m length of beach and then increasing the length of the survey transect in 10 m increments. Typically, in the first section sampled all types of litter are new and so the survey team will record a large number of new items. As the survey is extended it will become less and less likely that the survey team will find new classes of litter (i.e. types of litter that have not been recorded in previous sections that have been surveyed). Data from this sort of survey can be recorded as shown in Table 8 and graphed as illustrated in Figure 11.

Using these data as an example it can be seen that in the first 10 m section of beach, 25 individual pieces of litter were collected comprising 10 different types of litter. In the next 10 m section a further 26 litter items were found but this was less diverse comprising only 5 different types (of which four

[19] For example, many modern mobile phones now incorporate GPS technology particularly in the high-end brands but it is likely that this trend will extend to standard models over the next few years.

were new types and 1 type had already been recorded from the previous section). After surveying the third section a total of 30 m of beach had been surveyed; 32 litter items were collected again comprising 5 different types of litter but in this case only 1 type was new the remaining four having already been recorded from one of the preceding sections. This process is continued and it can be seen that by the time 80 m of beach has been surveyed then very few new items are being recorded for each section. In this case it would be reasonable to restrict the litter assessment to a 100 m section of beach.

Table 8. Illustrative data showing the variety of litter versus length of beach sampled.

Cumulative length of beach sampled (m)	Number of litter items in each section	Number of different types of litter in each section	Total number of litter types found
10	25	10	10
20	26	5	14
30	32	5	15
40	20	6	20
50	20	8	22
60	29	4	23
70	32	8	26
80	30	4	26
90	19	8	28
100	30	4	28
110	24	6	28
120	21	9	28
130	25	8	29
140	17	3	29
150	20	5	29
160	31	12	30
170	23	9	30
180	17	5	30
190	26	11	30
200	20	4	30
210	18	4	30
220	22	9	30
230	29	7	30
240	21	3	30
250	25	8	30
260	26	11	30
270	31	8	30
280	26	5	30
290	16	7	30
300	29	4	30
310	28	1	30
320	17	8	30
330	30	5	30
340	16	5	30

Where the amount of litter is relatively sparse, a larger sampling unit (i.e. 500 – 1,000 m or more) should be employed. The principal factor determining transect length for beach surveys is the signal to noise ratio. A sufficient length of beach is required to obtain enough data about litter items to provide a reliable estimate of loads. If sampling units are too short then the estimate is likely to be inaccurate, if they are too long then the sampling programme becomes intractable.

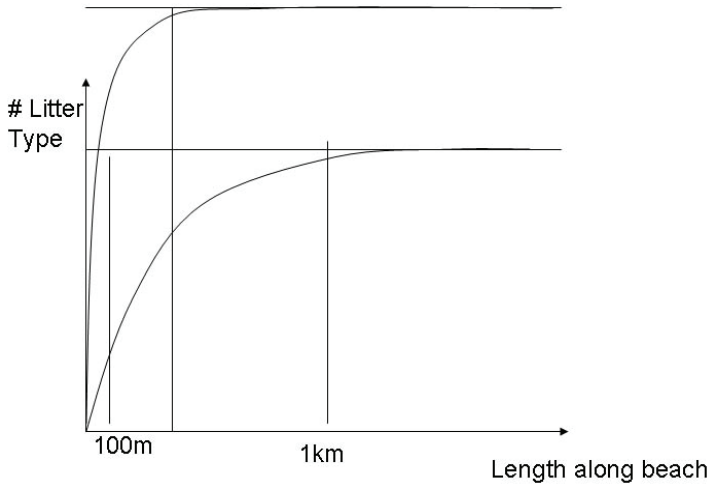

Figure 11. Litter type versus length of beach curves

Replication of sampling units varies substantially. For beach surveys it is typical to have between one and several samples per beach. The decision of whether or not to replicate sampling units at the level of the beach (i.e. whether to have one sampling unit or many) is largely determined by the desire to obtain spatially averaged samples. From a statistical stand-point multiple sampling units per beach may not be true replicates.

The NMDMP beach survey uses only one sampling unit per beach (i.e. beaches are considered to be replicates for a broader region).

Benthic litter surveys

The NOWPAP benthic survey considered areas of different sizes depending on whether the survey is a diver survey (10 m × 10 m) or trawl survey (1000 m × 1000 m). Conversely, the Hawaiian survey protocol employs manta tows that may vary substantially in length and therefore area covered, thereby focussing on the need to cover large areas.

The challenge for benthic surveys is to encompass the different needs for surveys in shallow nearshore areas against those in deeper water. The 10 m × 10 m units employed in the NOWPAP Benthic survey may be too small to be representative (particularly given the 1-3 sampling units recommended for each monitoring site[20]). Conversely, the manta tows used in Hawaii cover more area but are observers are likely to be moving too fast to obtain data any meaningful data on small litter items.

Floating litter surveys

There are no indications of sampling unit size in either of the floating survey protocols (FAP and Japan), although density calculation results for each observer period are presented for the Japanese operation (Shiomoto and Kameda 2005). Given the paucity of established models for floating litter surveys, our recommended approach follows that of Shiomoto and Kameda (2005). This is augmented with information from Ribic et al. (1992) wherein survey transects may vary in length and litter density is calculated based on estimating the number of litter items observed within a fixed horizontal distance from the vessel across the length of each survey line.

In a summary of eighteen floating litter trawl surveys, Ribic et al. (1992) found trawl distances ranging from 0.33 – 3 nautical miles and that mesh sizes were small (0.27 mm – 14 mm) and therefore

[20] NOWPAP do not provide a detailed specification of what a “monitoring site” comprises. On this basis it is problematical to evaluate the suitability of the proposed sampling strategy.

targeted small items. Consideration should be given to transfer of the NOWPAP Benthic approach to a floating litter survey with reference to the guidelines recommended by Ribic et al. (1992).

Although not included in the survey comparison, the “Fishing for Litter” initiative undertaken by OSPAR is worthy of note (OSPAR 2006).

7 Frequency

Across all survey types, sampling frequencies ranged from 0.5 – 12 months, although half the surveys undertook sampling on an annual basis (NOWPAP – Benthic, NOWPAP – Beach, ICC, WWF, FAP and the NDNHI). To some degree sampling may be constrained to a particular period, particularly at higher latitudes where the sea might be iced in over winter. Otherwise it might be argued that annual surveys lack the power to resolve marine litter questions at the level required for management/verification. Sheavly (2007) suggested that future beach litter sampling should investigate seasonal factors but also that sampling could occur less frequently in tropical areas. Quarterly surveys have been recommended for Australia (ANZECC 1996a; Cheshire and Westphalen 2007).

Pragmatically the organization required to support monthly surveys is unlikely to be universally available and on this basis quarterly surveys are the recommended sampling frequency for all survey types, although there are site specific issues that may require a longer interval (i.e. presence of ice) or result in a shorter sampling interval (regular maintenance clearances). As a minimum, each site should be sampled annually.

8 Sampling in line with specific events

Few survey protocols attempt to align sampling with specific natural events although in Korea, there is a litter capture programme (without formal data collection) that deploys fences across some river mouths prior to the onset of winter rains (Cho 2005).

While responses to specific events may be useful, the NMDMP stipulated a need for monthly litter samples to be collected within a short period of each other in order to support data analysis (Sheavly 2007). This requirement largely negates any opportunity to link sampling to specific events.

9 Ad-hoc reporting

With the exception of the AMDS protocol, other surveys do not provide a mechanism for *ad-hoc* reporting of litter items. In particular, floating litter (e.g. lost shipping containers or fishing nets) that may comprise a shipping hazard are frequently reported to local maritime authorities but currently there is no formal mechanism to capture these data. Other large scale litter events that come to the attention of the media might also be recorded.

Consideration could be given to developing an online system for *ad-hoc* reporting of litter items. Such a system may use a data recording sheet similar to that provided in the AMDS.

General criteria relevant to all survey types – Litter characterization

10 Size limits

Many litter surveys consider all litter items larger than 2.5 cm × 2.5 cm as this is the minimum disposal size permitted under MARPOL for ground shipping waste (Ribic et al. 1992). While the NMDMP includes this criterion, larger size limits are designated for some items (i.e. rope must be >1 m long to be included; Sheavly 2007). Conversely, OSPAR makes no distinction based on size, arguing that even small items (e.g. cotton buds or matches) provide useful information about littering that may be used to change behaviours and thereby better manage litter problems (it is worth noting that in some countries smoking has been banned from many suburban beaches).

Small, very common, litter items such as cigarette butts may present a logistic problem in terms of collection over the entire area of large (at least 100 m long) sampling unit, although smaller sub-units might be considered (i.e. 10 m wide strips of beach).

11 Litter categorization

The number of categories varies substantially across surveys, although there are arguably three quite distinct groups; Low resolution surveys that distinguish (1-6 categories) as seen in the two operational and floating litter surveys (CCI, FAP and Japan Floating); Medium resolution (30-60 categories) which includes most other surveys (NMDMP, NOWPAP – Benthic, KMMAF, CCAMLR and WWF) and High

resolution (90+ categories) which includes three surveys the AMDS, OSPAR and NOWPAP – Beach survey protocols (the latter using the NPEC data sheets).

The Hawaiian benthic survey (NDNHI) uses 250 categories, but these relate to the diversity of derelict fishing nets that were the specific target of that survey. Similarly, the Net Kit employed in Northern Australia as part of the WWF survey protocol (now operated by NRETA) contains more than 180 different net types that may be identified within litter collections (White et al. 2004).

In most cases classification of litter is based on a hierarchy that identifies items firstly by what they are made from (e.g. plastic vs. glass vs. rubber, etc) then by their form (e.g. bottles vs. sheets vs. fishing nets, etc) and sometimes also by size (e.g. long lengths of rope vs. short lengths). However, Sheavly (pers. comm.) has encouraged a different approach to litter classification wherein litter is grouped according to sources (i.e. a focus on managing littering behaviour rather than litter types)[21].

From a research perspective, the larger the number of categories that are considered the greater the capacity to summarise, analyse and interpret the data. In turn, this influences the range and complexity of questions that can be posed. Similarly, it might be argued that the use of only a few relatively broad categories makes targeting management to specific issues/industries/sources more difficult. However, the number of categories needs to be balanced against pragmatic/operational needs (e.g. experience and training of the survey team). There are therefore solid arguments for using a smaller number of categories as this simplifies training of the volunteers required to support surveys and time required in sorting time required at the end of each collection.

12 Litter summaries

Most surveys (10 of 13 – not FAP, CCI and Japan floating) aim to summarise data to report on litter composition. Form, size and indicator groups are sporadically employed (5, 4 and 5 surveys respectively) but the capacity to develop summaries is intimately related to the system by which litter items are classified (see 11 above).

A litter classification system for the operational guidelines outlined in this report was developed based on the alignment (wherever possible) of the litter categorization tables from eight different survey protocols (see Appendix C). The resulting matrix comprised more than 220 litter types and this was then refined to amalgamate similar categories, spread across up 10 broader classes primarily based on material composition of the litter, including:

- Cloth
- Glass, ceramics and pottery
- Foam (including sponge and packaging/insulation foam)
- Hard plastics (anything that has been moulded)
- Soft plastics
- Metals
- Rubber
- Paper and cardboard
- Wood
- Other (this group is not necessarily based on composition)

These broader classes each comprise from 5-14 specific types such that the 220 different groups identified across the various surveys is aligned with one of 77 litter types (see Appendix C for a summary) which form the basis for litter characterization in the recommended sampling guidelines for beach surveys. However, note that a further subset of these litter types was created (35 categories) to be used in surveys where the litter were remotely observed (and therefore the composition cannot be determined – see Appendix C).

[21] A properly configured relational database would provide lookup tables that could be used to re-aggregate litter types to support different analyses. Using this approach tools could be developed to aggregate data on the basis of sources, risks to wildlife, form, etc. depending on the purpose of the analysis being undertaken.

13 Quantifying litter

Irrespective of how litter is classified, there is a need to develop some system for quantification in order to provide a basis for comparison either between beaches/regions or within regions through time. Four approaches to quantification present as being practical for use in routine surveys although not all can approaches can be used for all types of litter. These four approaches comprise:

- Presence/absence of items within each litter type;
- Counts of items in each litter type;
- Weights of items within each litter type;
- Volumes of items within each litter type.

Most survey protocols recommend one or other of these with "counts" being the predominant approach. Irrespective of current usage, there are strengths and weaknesses associated with all of these approaches to measurement relative to different litter types.

Presence / absence

For some purposes it may be possible to simply record the presence of different classes of litter. In most cases this would not provide sufficient resolution to provide a meaningful interpretation and would not be recommended.

Counts of items within categories

Counts are relatively easy to make and they do not require any specialised equipment. In relation to litter items such as plastic drink bottles or plastic bags counts are arguably a very good indicator of importance. For remotely observed litter, counts within types are the only available approach.

Problems arise however when there are litter items within the same class that may differ substantially in terms of size. Counts of derelict fishing nets will grossly underestimate the significance of larger nets (Kiessling 2003) which may vary in size from less than 1 m^2 to 100s or even 1000s of m^2. In such cases counts are much less useful than a measurement of weight. Similarly counts are less useful for heavily fragmented litter items. How, for example, do you count a hundred pieces of plastic bottle – is it equivalent to one bottle or many? In such cases alternative measurements may be more appropriate.

Weights of categories

Superficially, measurements of weight may appear to provide an alternative to counts but similar problems apply. A simple statement that there is 100 kg of polyethylene sheet in a litter collection provides data on how much material there is but it is very difficult to relate this to management or the assessment of downstream risks unless you know what that 100 kg comprises in terms of individual items. If for example the 100 kg comprises 10,000 plastic bags each of which has the capacity to be ingested and kill wildlife then this represents a different scale of problem than if the litter comprises a single roll of material.

Similarly not all types of litter can be weighed, heavily fouled fishing nets or baulks of timber may weigh many tonnes. Practically these cannot be weighed unless the survey team has access to specialist equipment (that would not be routinely available). Furthermore, weights will vary (often substantially) depending on whether the material is wet or dry (particularly for cloth or ropes and netting).

Volume of categories

For some litter items (e.g. baulks of processed timber) estimates of volume are probably easier than any other approach. The dimensions of such items can be measured or estimated and this can then be quickly converted to volume. Similarly for tangled masses of discarded fishing net (which cannot be weighed), estimates of volume may be the best approach to quantification.

Is it necessary to use only one system for measurement?

The most obvious conclusion from the above is that different systems of measurement could be used for different classes of litter. While this approach to measurement is more work for surveyors in the field, the benefits from a litter management perspective may be substantial, particularly if litter characterization is subject to a regular process of review such that survey effort refines the focus to those litter items of particular management concern.

For comprehensive research surveys, where the survey is carried out by a trained team, this is not an unreasonable proposition but for most surveys there is no certainty that people involved will be able to quickly adapt from one form of measurement to another.

An alternative approach adopted in some surveys (notably the WWF in northern Australia and the AMDS) is to make multiple measurements (e.g. weights and counts) and to use these measurements to calculate other factors such as volume.

Counts of items within categories occur in virtually all litter surveys (not the FAP which does not investigate the collected litter). Litter weight was considered in five surveys (AMDS, NOWPAP – Benthic, CCAMLR, WWF and FAP), the ICC survey also recorded total weights of litter, while three surveys (OSPAR, CCAMLR and NDNHI) considered counts within size classes (a hybrid of counts and volumes).

For trawl surveys catch per unit area would be the most robust approach to quantification (Ribic et al. 1992), but this parameter does not appear to have been employed in the only current trawl survey protocol (NOWPAP – Benthic).

Recognition that neither counts nor weights alone are necessarily sufficient has also resulted in changes to classification of litter. Data on the size frequency distribution of derelict fishing nets may be obtained across a number of bins (e.g. counts of nets with sizes in the range such as < 5 m^2, < 20 m^2, < 100 m^2, ≥ 100 m^2). Such data may be much more amenable to interpretation and provide a more coherent basis for management interventions as large numbers of small nets may suggest they are being fragmented by a highly energetic local environment or that they have been in the system for a longer period of time and may have come a substantial distance from their source. Conversely larger, and probably more environmentally damaging nets, are more likely to have a local source which may lead to a more direct management intervention.

14 Litter sources

The term “litter source” has been used variously in the literature to mean either *the user-groups* that are littering or alternatively *the point of manufacture or origin* of a litter item.

“Litter Source” in the ICC and NMDMP surveys was determined by categories of user-groups (boaters, fishers, beach goers, etc.). Identifying such sources of land-based and ocean-based provides a useful and functional approach to assessing how an item becomes marine litter and its associated source. Indicator items are used in both the ICC and NMDMP to relate litter to user-groups. Identifying sources in this manner leads to the development of practical management tools to target the behaviours of groups that are littering and change this behaviour accordingly.

The classification of litter based on the point of manufacture or country of origin is arguably of less value. It has been suggested that within a global marketplace, tagging items with a country of production is not likely to provide a practical or functional approach to management of litter. This argument is reflected in the decision by OSPAR to abandon source identification owing to the time and resources required.

Conversely, the AMDS provides for the collection of information on the point of manufacture or origin of litter items based on barcodes, address labels and other identifiers (Cheshire and Westphalen 2007). The AMDS also makes provision for the use of the net-kit identifiers developed under the WWF protocols and used to classify fishing nets and thereby to identify sources (industry sector that uses that particular type of net). In countries like Australia, where relationships with industry are well established, it is possible to differentiate litter items used by domestic operators from those that have come from foreign operators. This is particularly true of discarded or derelict fishing nets which comprise a major environmental hazard particularly, for example, in northern Australia.

From a logistics and data management perspective, the value in identifying sources is likely to vary from region to region. In areas such as Australia where a substantial component of the litter is not of local origin, country of origin identification provides the basis for international discussion and negotiation. In areas such as Europe, where much of the litter is of local origin and source information (country of origin) is of little practical use when compared to other approaches such as understanding discard behaviours. Furthermore, given the increasing globalization of trade, speed of transport and increasing diversity in ethnicity within population centres worldwide (and consequently the variability, particularly amongst food related litter), source information of this kind is likely to become less valuable over time.

Conversely for litter items that are widely accepted as being both seriously widespread and ecologically damaging, such as fishing nets, identification of the source (in this case the fishery) responsible may be a key element to the development of management strategies. Consequently, the investigations into net types and origins as explored in northern Australia and Hawaii may be worth further consideration and expansion (see White et al. 2004, Timmers et al. 2005).

At the other end of the scale, plastic shopping bags are widely seen as ubiquitous and environmentally damaging but there is no mechanism for identification of sources. It is likely that alternative approaches to management are needed (e.g. to focus on legislative arrangements such as the recent proposal to ban plastic shopping bags throughout the whole of Australia by the end of 2008, see http://en.wikipedia.org/wiki/Plastic_shopping_bag#_note-6, Accessed February 2008).

15 Identification tools

Three surveys have guides to assist litter classification (note this should not be confused with field guides that assist in conducting a survey – see below). As discussed above the WWF surveys in northern Australia developed "the Net Kit" an identification guide for derelict fishing nets (White et al. 2004), to be used in conjunction with beach litter surveys. This guide helps quantify the profusion of nets into manageable categories and may ultimately assist in targeting management at the sources. This guide models similar approaches used for fishing nets clearances in the northwest Hawaiian Islands (Timmers et al. 2005).

OSPAR used an online Marine Litter Guide; www.marine-litter.net/guide/guide.htm but this is no longer operational (as of July 2008).

On a less formal front, datasheets often include images of each litter item (see the WWF protocol – White 2005).

16 Entrapped fauna

Many surveys (7 in total; AMDS, NMDMP, NOWPAP – Beach, KMMAF, ICC, WWF and NDNHI) require data on any entrapped fauna to be included as part of the survey although there is often a lack of clarity as to what animal groups are to be included. In northern Australia, the focus is largely on marine reptiles (White 2005), although other organism may be included. Otherwise, although the threat posed to wildlife is readily acknowledged, most reporting would appear to relate more to marine mammals, reptiles, birds and possibly sharks and rays (see Timmers et al. 2005) rather than bony fish and large mobile invertebrates (large crustaceans, molluscs, etc), although the physical damage to corals has been noted in Hawaii (Donohue et al. 2001).

Entanglements need to be identified and should be included as part of the "Additional notes" section of a survey, with the associated guidebook outlining reporting requirements with respect to animal type, tangle type and status (alive or dead).

17 Large litter items

Five surveys (AMDS, NOWPAP – Beach, ICC, OSPAR and WWF) make allowances for large items of litters (e.g. car bodies, very large fishing nets, baulks of timber etc). Large items, floating, sunken or beached are unlikely to be removed even assuming equipment and funds are available. In those surveys that address this issue it is generally recommended that the character and position (preferably GPS fixed) of large objects should be noted in as much detail as possible, such that the item can be mapped and excluded from future surveys (and also be reported as a potential hazard in the case of floating litter).

The key issue from a litter sampling perspective is that such items are included only once, when they are first observed.

Municipal agencies might be engaged to remove these items at a later date.

18 Large natural litter items

Only one survey (Japan floating debris survey) made allowance for trees and foliage that were encountered. Otherwise, naturally occurring woody litter is rarely reported as part of the litter data. Given that the source of natural woody litter is unlikely to be established, and that the process by which it arrived may be natural, there would seem to be little need to gather such data.

19 Sampling effort

Almost all surveys (excluding the NOWPAP – Benthic or FAP surveys) recorded the number of persons engaged in litter collection and many also collected data on the time taken to complete each sampling unit.

For the NMDMP, the time taken to complete the survey is recorded but the number of people involved is not (Sheavly 2007). However, this protocol used two different methods for completing a 500 m sampling unit depending on the number of persons involved. Survey team members form skirmish lines either at right angles to the coast (2-5 persons) or parallel to the coast (>5 persons), which presumably helped to keep the effort roughly the same.

General criteria relevant to all survey types – Logistics and capability

20 Field staff

Most surveys (AMDS, NMDMP, NOWPAP – Beach, OSPAR, CCAMLR, OSPAR, CCI and NDNHI) try to use the same personnel in subsequent surveys (note the Japan Floating Litter survey was a one-off). Sheavly (2007) noted however, that the staggered initiation of the NMDMP meant that some locations were surveyed for more than ten years, making the maintenance of volunteer enthusiasm and continuity quite difficult, with a concomitant need to find and train replacement field teams.

In this respect the NMDMP probably offers the best example of a large scale litter survey that was reliant on voluntary input. In a summary report, Sheavly (2007) concluded that volunteers were effective, but that efficiencies could be greatly enhanced through integration of the sampling within local resource management programs, which would include support from national parks, resource managers, fisheries and tourism managers as well as non-government organizations.

It needs to be recognized that volunteers typically come from a wide variety of backgrounds; by way of example the NMDMP volunteers included retired corporate executives, technicians, educators, local conservation organizers, middle and high school science classes, college students, U.S. Naval and Coast Guard offices and other members from the private sector (Sheavly 2007).

This diversity will bring with it differences in knowledge and experience and these need to be addressed when developing a volunteer programme. In summary there are a number of key issues that need to be considered when engaging volunteers in marine litter assessments and these include (adapted from Sheavly 2007):

a. Volunteers need to be properly trained with hands-on training exercises and supportive training materials and programme manuals that detail responsibilities and procedures.
b. Local coordination and management is needed to ensure that volunteers are available when needed and monitoring schedules are followed.
c. Effective and frequent communication is a key element in keeping volunteers engaged and up-to-date with the programme activities, including how their monitoring activities are supporting resource and conservation management efforts.
d. Succession plans are needed to ensure that as some volunteers retire or leave the programme, new volunteers are trained to provide replacements.
e. Regular recognition efforts (media coverage, presentations by monitoring group members and/or management groups at local civic meetings, thank you notes, various memorabilia including t-shirts, hats, etc.) of the volunteers and their efforts can be effective in maintaining their involvement in the monitoring programme.
f. The monitoring programme needs to be realistic as to expectations of labour and the length of time needed to conduct this type of study.
g. Programme managers need to make regular visits to sites to ensure that training is relevant and appropriate to the needs of the survey. Ideally follow-up visits should be scheduled to coincide with re-training efforts and other activities.
h. Volunteer managers, who may often be volunteers themselves, need appropriate training to ensure that they have the skills to manage a volunteer workforce.
i. Ideally local partnerships may be developed with state or municipal agency staff to facilitate the monitoring and integration of volunteer management, training and programme delivery.

j. Where appropriate, typically for remote surveys or where local people are limited by financial or other resources, monetary support may be required to cover transportation expenses related to their efforts.
k. While the very nature of a volunteer is not to expect anything in return for his/her efforts, people do like to know that their efforts are meaningful and appreciated.

In more general terms the following issues are also relevant when managing volunteer programmes (adapted from the "Model Code of Practice for Organisations Involving Volunteer Staff"; Volunteering Australia 2007):

a. Interview and employ volunteer staff in accordance with anti discrimination and equal opportunity legislation;
b. Provide volunteer staff with orientation and training;
c. Provide volunteer staff with a healthy and safe workplace;
d. Provide appropriate and adequate insurance coverage for volunteer staff;
e. Define volunteer roles and develop clear job descriptions;
f. Differentiate between paid and unpaid roles;
g. Provide appropriate levels of support and management for volunteer staff;
h. Provide volunteers with a copy of policies pertaining to volunteer staff;
i. Provide all staff with information on grievance and disciplinary policies and procedures;
j. Acknowledge the rights of volunteer staff;
k. Offer volunteer staff the opportunity for professional development;
l. reimburse volunteer staff for out of pocket expenses incurred on behalf of the organization;
m. Treat volunteer staff as valuable team members, and advise them of the opportunities to participate in agency decisions; and
n. Acknowledge the contributions of volunteer staff.

21 Staff training

Only the NMDMP protocol specifies a field training regime for its volunteers, which required a substantial effort on the part of the lead agency (Ocean Conservancy) in terms of identifying and recruiting volunteers and then training them *in situ* (Sheavly 2007).

While CCAMLR indicate that staff undertaking the survey are "appropriately trained", there are no details as to what this comprises, but it may well refer to safety issues (given that the survey occurs in remote Antarctic locations) rather than to the litter survey protocol.

Consistent, high quality training at the management and field level is essential to quality assurance and control over the data. Education of staff should include information on the results of surveys such that staff can understand the context of the field programme.

22 Manuals and training tools

All large scale marine litter surveys have manuals and/or field guides to assist volunteers, most notable are those developed for the ICC and NMDMP (The Ocean Conservancy 2002, US Environment Protection Agency 2002, Sheavly 2007).

Field guides and litter identification tools are an important element in the maintenance of sampling consistency. Importantly, care should be taken to ensure that the development of guides is sensitive to language and cultural issues. For example, guides for surveys involving indigenous Australians should not contain images or names of deceased persons. Issues of this nature highlight the need to obtain the support of locally based managers as the point of liaison between volunteers and higher level survey management.

23 Quality assurance / quality control of the data

Few marine litter surveys (only 2 of the surveys considered) have mechanisms for assuring data quality, which is of concern given the high level of voluntary help that is engaged (Ribic *et al.* 1992). The OSPAR survey has a quality assurance programme based around a "Checklist" approach to surveys assisted by multilingual, illustrated online support (OSPAR 2007). The NMDMP has a built in quality assurance protocol conducted by survey managers (who take responsibility for each site) such that a proportion of all location/month combinations are checked, and data errors identified (US Environmental Protection Agency 2002, Sheavly 2007).

Development of a quality assurance programme within a large scale litter survey is essential, particularly given that language and cultural differences will present challenges for data integration and exchange.

24 Logistic and technical support

Eleven of the survey protocols incorporated engagements with external partners. The exceptions were either contained within the respective organization (CCAMLR, which operates in a very remote locations) or comprised a one-off survey (Japan floating litter). Most litter surveys, particularly beach clearances, engage with a range of stakeholders that may include individuals, community groups, industries and government organizations (Cheshire and Westphalen 2007). In most instances, the on ground component of a survey is relatively straight forward in terms of being completed by non-technical persons. However, responsibility for data collation, quality control, analysis and development of reports and provision of expert technical advice is often more problematic.

External support in terms of data collation, management, analysis, interpretation and reporting is essential for a large scale litter programme. These services may be offered by a dedicated marine litter framework such as that offered by the ICC or include engagements with universities, government science agencies and/or international organizations (such as UNEP).

25 Centralised data storage

In line with the above, all surveys except the AMDS and NDNHI (although note that these surveys were excluded as they don't explicitly state this) maintain a centralised data collation, management, quality assurance and storage platform. Capacity for online access to the data by stakeholders was not explored, although the ability to see the results of surveys may be an important element in maintaining volunteer enthusiasm.

A centralised database should have capacity to interface with data from existing marine litter survey programmes. While the systems used to characterise litter vary between surveys, these differences can be circumvented through a translation table (see Appendix C). Although the design of a centralised database is beyond the scope of the current reporting, the basic structures can be readily identified, including:

Organizations – who is engaged in surveys?

Locations – where surveys are undertaken, include specific details of the site that are independent of litter surveys.

Surveys – when surveys were undertaken, including data relative to the specific survey (number of persons involved, etc).

Survey data – what the surveys found in terms of marine litter.

Information/translation tables – such as relating litter types to those employed other surveys.

26 Online support, data entry strategy and reporting interface

Five of the surveys maintained an online presence that can assist in advertising awareness of marine litter issues (NOWPAP- Benthic, NOWPAP – Beach, NMDMP, ICC and OSPAR), report results of surveys and serve to advertise future activities. Online support often includes guides for field operations including detailed survey protocols as well as the capacity to both upload and review data in some instances.

Notably, Ocean Conservancy has a substantial online presence for their ICC Program (http://www.oceanconservancy.org/site/PageServer?pagename=press_icc), which includes summary reports for each country. The NMDMP has an extensive online presence (http://www.oceanconservancy.org/nmdmp) with data listings and summaries covering the life of the study (Sheavly 2007).

27 Data collection during or post beach collection

Many surveys (9 of those considered – not OSPAR, CCAMLR, Japan floating, FAP and the CCI) collect litter from across a sampling unit and then collate and characterise the gathered litter (either using weights or counts or both). Alternatively data can be recorded without collecting items (counts only) or while the litter is being collected. In some cases this is faster but it depends on whether the material is heavily fragmented and whether or not support vehicles or similar are available to carry litter back to a sorting location.

Data on entanglements and large immovable items is generally best collected as they are encountered.

28 Datasheets

The AMDS maintained the largest number of datasheets (up to 10), but this reflects the comprehensive nature of the database being designed to support both research and community oriented surveys from either discrete sampling units or whole beaches and included a capacity for *ad-hoc* reporting, source reporting and information about entanglements. It should be noted that once a research site had been set up, a survey within the AMDS required (at most) four datasheets (Cheshire and Westphalen 2007) for the comprehensive research survey and only 1 datasheet for community based surveys.

Four surveys kept their data sheets to one double-sided page (NMDMP, NOWPAP – Benthic, KMMAF and the CCI), although this almost certainly poses limits on the amount of incidental information that can be gathered.

It also needs to be noted that the establishment of new sites for both the OSPAR and NMDMP required a range of data that are not included on the standard survey sheets.

Ideally, a survey should be undertaken with as few a number of datasheets as possible.

Beach surveys

29 Beach selection criteria

Six of the nine beach survey protocols (AMDS, NMDMP, NOWPAP – Beach, KMMAF, OSPAR and CCAMLR) use criteria for the selection of beaches. At a basic level these relate to the need for modest slope such that the width of the beach at low tide is not extreme (i.e. not a tidal sandflat where surveyors could become stranded or worse still overtaken by the tide as it comes in), the beach has to be long enough length to include the sampling unit(s) and the beach should not be subject to other clean up activities, although this is difficult to achieve in many areas. The NMDMP goes further to include a number of facets related to exposure to open sea, substrate types (generally sand only), accessibility for survey team members (generally volunteers) and limiting risks to endangered flora and fauna (Sheavly 2007).

Some consideration needs to be given to beach selection criteria, although the degree to which these constraints might affect litter accumulation must be included. This relates in particular to restrictions on beach slope as this factor will have a direct relationship to the wave energy and the depositional nature of the site.

30 General depositional nature of the beach

There are a large number of factors that indicate or are related to the depositional environment of a given beach, including; local and offshore currents, slope, aspect, length, tidal range, prevailing wind, etc. OSPAR (2007) indicate that a generalised questionnaire was used to determine the nature of each beach, although the actual data collected are not explicitly specified. Cheshire and Westphalen (2007) developed a comprehensive list of parameters, although it may be argued that not all of these factors are necessarily important with respect to litter deposition. The NMDMP obtains some information on the depositional nature of each beach (in particular the conditions at the time of and immediately preceding each survey) but the specific descriptors are not clearly documented. The summary report (Sheavly 2007) does not make any inferences related to the depositional/energy environment in terms of litter fluxes.

Three beach surveys (NOWPAP – Beach, ICC, WWF and the ICC survey) collect no data on the depositional environment, which restricts the capacity to develop meaningful comparisons between locations (although note that these data do not apply to the CCI survey). Care should be given to employ descriptions of differences between survey sites in lieu of depositional data. Like litter characterization (see above), there is a need to develop standardized minimum criteria for describing the nature of each beach environment as even when data are collected, surveys vary substantially.

31 Conditions at the time of the survey

The prevailing conditions at the time of the litter survey are considered to be important by some (Cheshire and Westphalen 2007, Sheavly 2007), although relatively few surveys appear to collect any

data (and only the AMDS is comprehensive). The NOWPAP – Beach, OSPAR, ICC, WWF and CCI protocols do not collect any data on this aspect.

32 Anthropogenic influences

Anthropogenic factors include access (pedestrian, vehicular or boat), location (urban, peri-urban or rural) and proximity to sources (rivers, streams and towns) amongst others. These factors are yet another example of variables that may be included when comparing between locations, but again there are relatively few beach survey protocols that invest resources in obtaining these data (note the AMDS and OSPAR protocols are exceptions in this respect).

33 Defining the landward edge of the survey

Beach surveys tend to collect litter from between the water level (preferably at low tide[22]) to what is frequently called the "back" of the beach. The latter appears to infer a limit defined by the presence of dunes, vegetation or a cliff base (see Sheavly 2007) but in some instances the landward limit of a beach may be anthropogenic (i.e. a road, seawall or fence). Many surveys consider one or more of a number of factors, but few consider more than natural limits, and none are comprehensive. In some beach surveys (OSPAR and the ICC) this limit does not appear to have been adequately defined.

Whatever the limit may comprise, it is important that this information is noted for each sampling unit. Firstly as this is yet another factor that may account for variation between beaches but also so that consistency in data collection is maintained.

Given that the width of each sampling unit will vary according to the landward constraint, litter characterization should favour reporting litter per unit of beach length rather than an areal basis.

34 Defining the seaward edge of the survey

Like the landward limit, beach surveys are often vague as to what defines the seaward limit of the sampling unit. It is a reasonable assumption that the water edge at the time of the observations forms a natural constraint and this has been used by most surveys (5 in all; AMDS, NMDMP, CCAMLR and CCI), although the tidal differences at the time of the survey will alter the width of the sampling unit between surveys. Otherwise, litter collections at low tide are certainly recommended (Sheavly 2007, CCAMLR 2008).

Given that the tide will continuously alter the width of the beach, sampling units should be kept to a length such that the difference in tidal height over the sampling period is limited. Changes in beach width during the survey add further weight to the need to report litter on per unit of beach length rather than area.

Benthic and floating litter surveys

There are too few benthic (NOWPAP – Benthic, NDNHI) and floating litter surveys (FAP and Japan) available for development of meaningful comparisons. For this reason, the analysis of these sampling strategies includes reference to the broader literature and particularly to the descriptions and recommendations provided by Ribic et al. (1992).

Benthic surveys

35 Observation/data collection platform

Benthic surveys may occur as either trawls or non-collecting remote observations, with the latter including divers/snorkelers, camera tows or submersible platforms. Side scan sonar has also been employed in benthic litter assessments, notably in relation to the fallout from Hurricane Katrina (NOAA 2008).

In Korea, a deepwater camera sled operation has been used to assist targeting of trawl operations (Cho 2005). Similarly the NOWPAP Benthic survey recommends a "pre-survey" of a broader area (~ 5000 × 5000 m) within which 1-3 trawls are targeted (~ 1000 × 1000 m areas each; NOWPAP 2007a).

[22] Caution needs to be taken with beaches that have a shallow slope as the low tide mark may be quite distant from land and surveyors may become stranded by the incoming tide. Ideally however, such beaches should not be selected for survey.

36 Litter collections

Other than benthic trawls, divers and snorkelers may also undertake clearance operations either from within discrete sampling units (NOWPAP 2007a) or on a less structured basis as in the surveys undertaken for the removal of fishing nets from Hawaiian reef systems (Donohue et al. 2001, Timmers et al. 2005). The ICC also collects underwater surveys conducted by divers/PADI Project AWARE (Sheavly pers. comm.).

Litter collection by divers/snorkelers entails a number of additional safety aspects over and above those related to recreational diving/snorkelling.

37 Targeted to specific locations (substrates, currents, etc)

The Northwest Hawaiian Island survey (NDNHI) targeted shallow, coral reef systems, while NOWPAP – Benthic considered both nearshore diver and deep water trawls within provinces of each of the member states.

Like beach surveys, broader scale benthic surveys should be targeted at specific locations that are themselves embedded within broader regional units, with a view to obtaining repeated observations related to currents, land forms and proximity to sources.

38 Nature of the seabed

The nature of the seabed is an important factor in defining the nature of the benthic survey with respect to the litter that might accumulate as well as the approach to sampling (Ribic et al. 1992). It needs to be recognized that benthic trawl operations are not without the risk of environmental damage to sessile communities but may also present risks to trawl operators with benthic snagging and associated equipment loss.

39 Nature of trawl gear

Trawl gear may comprise nets, grapples, rakes and similar (NOWPAP 2007a), with each targeting different broader types of litter (Ribic et al. 1992). The relative differences in sampling effort between different gear types needs to be established if comparisons are to be achieved. Importantly, the nature of the vessel, trawl gear and transect characteristics (speed, length of tow, etc.) are important factors in determining the Catch Per Unit Effort (CPUE) for each haul (Ribic et al. 1992). This is an important standardising factor when comparing between litter samples.

40 Field of view angle

The field of view relates to the width, measured as an angle from the point of view of the observer, through cameras or windows and thus relates to camera tows, submersibles and to a lesser degree, observations by divers. When considered in conjunction with the viewing distance (as determined by visibility) the area covered by the observations can be calculated (e.g. a 500 m towed camera with a 4 m wide field of view represents a survey area of 2,000 m^2). Although camera tows are relatively popular for benthic litter surveys there is no published information on key parameters such as the nature of the camera, the field of view, angle relative to the seabed, etc.

The Hawaiian observations of ghosts nets, made extensive use of snorkelers on manta tows (Donohue et al. 2001), in these cases the horizontal width of transects (and thus the area covered) is variable and ultimately determined by the observers capacity to swerve from side to side.

41 Limits on visibility

Visibility limits on diver, submersible and camera observations are critical to determining the area of coverage accomplished within a survey (Ribic et al. 1992). Manta tow surveys in Hawaii report visibility limits at the start and end of each transect (Donohue et al. 2001).

Floating litter

Floating litter surveys may comprise observations of litter from surface vessels or aircraft, but in either case none of the litter is collected (e.g. Shiomoto and Kameda 2005). Alternatively floating litter surveys may comprise surface trawls. No examples of the latter were available for comparison.

42 Observation/collection platform

Floating litter observations or trawls may be undertaken from vessels, although aircraft (planes or helicopters) may also be employed. It should be noted that the use of aircraft in litter assessments is

not necessarily limited to floating litter. The Carpentaria Ghost Nets Program has used helicopters to assess the distribution of derelict fishing nets on beaches in remote locations (Anon 2006).

43 Repeated target survey (same route)

The survey of floating litter around Japan (Shiomoto and Kameda 2005) appears to be a one-off survey and as such one cannot make inferences about variation through time. While the Floatables Action Plan (US Environment Protection Agency 2007) uses spotter aircraft to direct skimmer vessels, there appears to be limited data capture within this survey (note that litter characterization is not an objective of this survey).

Clearly repeated observations of the same areas, in particular specific currents and proximity to sources would be required to obtain an understanding of floating litter dynamics.

44 Nature of the observation platform and samples

Information on the nature of the observation platform is critical to comparing litter assessments between different vessels or aircraft (Ribic et al. 1992). This includes the position, field of view, height above water and other factors that affect the sample (such as speed, direction, time period and maximum viewing distance). The Japanese study employed the same vessel throughout and therefore had no need to collect vessel specific data (Shiomoto and Kameda 2005). However, unlike other sea based surveys, floating litter observations could be collected from different vessels that might travel the same route, in which case ship-related differences would be important.

45 Conducted in association with other observations

For some surveys other observations (e.g. marine mammal counts or seabird activity) might be incorporated along with litter assessments.

46 Vessel, gear and sample characteristics for trawl operations

Comparisons of results from trawl based surveys need to consider differences in the characteristics of the vessel used to undertake the survey as well as differences in trawl gear specifically including mesh size, net size and depth of tow (Ribic et al. 1992). Each of these factors has the capacity to change both the sample size and the sampling effort. Similarly, vessel speed, direction and position are critical factors with respect to sampling units (Ribic et al. 1992). Importantly, the nature of the vessel, trawl gear and transect characteristics (speed, length of tow, etc.) are important factors in determining the Catch Per Unit Effort (CPUE) for each haul (Ribic et al. 1992), which is an important standardising factor when comparing between floating litter sampling results.

Analysis and interpretation

The preceding demonstrates that, while there are many differences between the various survey protocols, there were also a number of unifying features.

In terms of the beach litter surveys, four sets of protocols stand out as being quite detailed (high degree of specification) these being AMDS (the most highly prescribed system), NMDMP, OSPAR and CCAMLR. A second group, with a much lower level of prescription in survey specifications comprise WWF, KMMAF, ICC and NOWPAP – Benthic. The final group comprises the CCI protocol which is very different from most others having a focus on operational clean up of beaches as opposed to litter surveys.

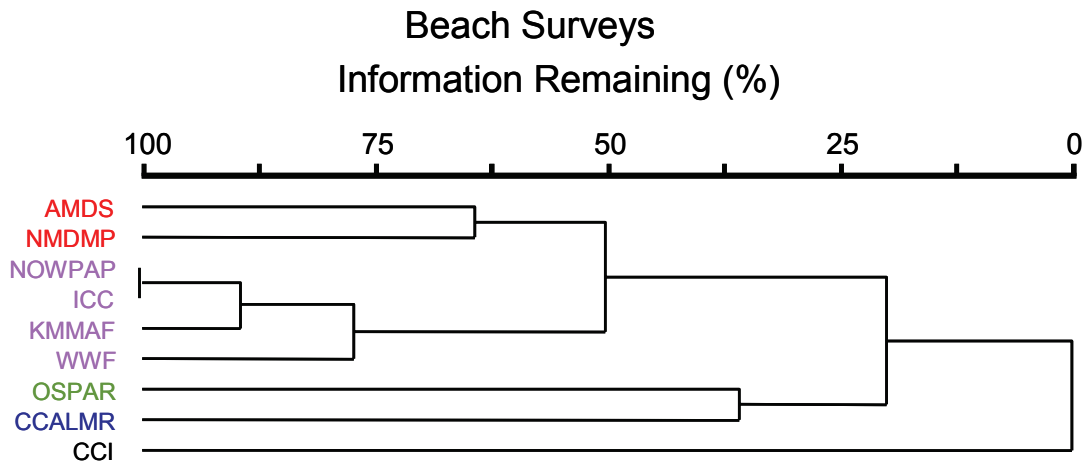

Figure 12. Cluster analysis illustrating the relationship among survey protocols. Protocols are linked together according to their relative similarity using the data obtained from a comparative analysis of all beach surveys. The CCI protocol is an outlier (dissimilar to other protocols) which reflects its principal focus on operational clean up. AMDS, NMDMP, OSPAR and CCALMR are protocols with detailed specifications whereas the NOWPAP, ICC, KMMAF and WWF protocols are less prescriptive.

In order to provide a simplified summary of the similarities and differences between the various surveys a multivariate analysis of survey protocols was undertaken. Data relating to the key comparative criteria were assembled into a set of numerical indices (for criteria with a yes/no answer these were simple binary indices) and this data set was then analysed using a classification analysis (McQuitty's algorithm on a relative Euclidean distance matrix).

The resultant plot (Figure 12) illustrates the relationships between the protocols as discussed above. In general terms the objective in developing a unified set of guidelines can only be achieved by identifying a good compromise between prescription and pragmatism and learning from programmes that have a proven record of successful application.

Principal issues to be resolved in developing standardized operational guidelines

Findings from review of existing guidelines

It is evident from that there has been a much greater effort put into developing specifications for beach litter surveys (see for example Ribic et al. 1992, Rees and Pond 1995, ANZECC 1996a, Kiessling 2003, Stuart 2003, Cheshire and Westphalen 2007, Sheavly 2007, NOWPAP 2007b) than has been invested into developing guidelines for the assessment of either floating litter or benthic litter.

A number of the surveys have been designed to support large scale, longer term surveys, including the AMDS, OSPAR and NMDMP protocols (Cheshire and Westphalen 2007, OSPAR 2007, Sheavly 2007). The higher level of complexity in the design and implementation frameworks for these surveys reflect an increasing need to better manage marine litter problems as well as to better quantify ecological and ecosystem threats.

The development of a standardized set of operational guidelines for marine litter assessment required the resolution of a number of principal issues as summarised below.

1. Development of a standardized scheme for classification of marine litter which needs to consider how items are best categorised with reference to either:

    a. A hierarchy of material composition and form and/or

    b. Litter sources.

2. There is a need to define how litter will be quantified and whether or not there is a need to apply the same principles to all classes of litter. Candidate quantification schemes include:
    a. Presence/absence of litter items within a class.
    b. Weights of items within a class.
    c. Counts of items within a class.
    d. Combination of weights, counts and potentially volumes of litter items within each class.

3. Survey effort should be standardized or quantified in order to adequately define the basic sampling unit. Options include:
    a. Area of beach – not preferred as the amount of litter is more related to linear distance of beach surveyed rather than the width of the beach.
    b. Distance along a beach – generally a preferred method but cannot be prescribed due to substantial differences in litter load between regions.
    c. Use of a hierarchy of scales based on item size as per the OSPAR system.
    d. Standardize sampling effort by using a fixed number of person hours per sample. This could account for differences in litter loading and may be the best compromise.
    e. Defining sampling units on the accumulation rate of litter types versus the length (or area) of beach considered.

4. The length of time between sampling events at any given location needs to be defined. The major challenge will be to balance survey effort with timing to obtain reasonable and comparable estimates of flux rates (the rate at which new litter items accumulate on a beach). Likely alternatives are either monthly or seasonally (e.g. quarterly). It may be possible to define the minimum frequency but to allow for more frequent surveys in some areas. Given that beach surveys in many areas must work around municipal cleaning, sampling frequency needs to be flexible.

5. Regionalization systems for surveys need to be developed consistent with information on major currents, coastal features and proximity to litter sources, although the latter issue could form a component of stratified sampling within regions (Sheavly 2007). It is also important to consider a broader suite of issues that need to be encompassed when extending the regional context of surveys including the need to address logistic and cost constraints for developing countries.

6. Having identified a need for larger scale, longer term litter studies, there will be a need to develop a management framework through the designation of a lead agencies with responsibility for:
    a. Identifying sampling locations;
    b. Identifying and engaging with stakeholders at the national/regional levels;
    c. Establishing a litter sampling management framework (i.e. the hierarchy of responsibilities within a region). This will include defining sampling locations, the recruitment and training of volunteers and establishment of lines of communication;
    d. Development and implementation of a data management and reporting platform.

    Whereas the Ocean Conservancy's International Coastal Cleanup may provide a good framework through which some of the above can be achieved, there are some critical issues that will need resolution.

    It is apparent that the published descriptions of many marine litter survey protocols do not provide comprehensive specifications for many of the background or framework issues associated with the national or regional scale integration of survey results. This issue is seen most clearly when comparing the OSPAR (OSPAR 2007) or NMDMP (Sheavly 2007) survey protocols with the AMDS (Cheshire and Westphalen 2007) protocols. In developing the specifications for the AMDS a great deal of work was put into providing specific details of the

design and operation of a suitable relational database system and the associated data recording frameworks.

It is almost certain that some of the other protocols, particularly those that operate at national or regional scales, have considered these issues but the documentation is not readily available. Indeed, in developing the AMDS protocols, Cheshire and Westphalen (2007) had to undertake a separate analysis of the NRETA[23] and CCAMLR database and data specifications. It was found that they similarly had a complex set of specifications but that these were implicit and had never been extensively documented. Such issues will present significant challenges for the future development and maintenance of marine litter database systems.

In moving to develop a set of unified operational guidelines for marine litter surveys such issues will need to be made explicit and work will be needed to develop specifications relating to database structures, storage and management.

7. Standardized litter categorization and measurement

   Probably the most critical factor limiting comparisons between current surveys are the profound differences in litter characterization. The development of a standardized set of litter categories and measurement criteria will enable data integration and analysis across regions, allow backtracking of litter to sources, the determination of ecological threats and the development of management strategies.

   It may be that existing surveys should be encouraged to continue in a more or less unaltered format, but with the provision that litter data is collected with reference to the standardized categories that can be readily translated to the survey-specific forms.

8. Greater understanding of the depositional nature of survey sites

   For most litter surveys, irrespective of the type, there is a lack of emphasis on measurements related to the depositional nature of the sample locations. There is thus a considerable difficulty in making comparisons between locations as potential sources of variability are not included.

[23] NRETA is a government department in the Northern Territory of Australia (Natural Resources, Environment and the Arts) which manages the NT database on marine debris.

Table 9. List of the criteria and responses for a selection of large scale, long-term marine litter surveys.

Number	Part	Key issue	Detail	Variable	AMDS	NMDMP	NOWPAP – Benthic	NOWPAP – Beach	Korea	ICC	OSPAR – Beach	CCALMR	WWF	Japan	FAP	CCI (Israel)	Hawaii
		Survey Basics															
1	a	*Does the survey protocol relate to;*	*Community awareness programme*	y/n	y	n	y	y	y	y	n	n	y	n	n	y	y
1	b	*Does the survey protocol relate to;*	*Research program*	y/n	y	y	y	n	y	n	y	y	y	y	n	n	y
1	c	*Does the survey protocol relate to;*	*Operational assessment*	y/n	n	n	n	n	n	n	n	n	n	n	y	y	n
2	a	*Does the protocol consider;*	*Standing crop*	y/n	n	n	n	n	n	n	n	n	n	y	n	y	n
2	b	*Does the protocol consider;*	*Flux rates*	y/n	y	y	y	y	y	y	y	y	y	n	y	n	y
3	a	*Does the survey target locations within specified regions;*	*Bioregions*	y/n	y	n	n	n	n	n	y	n	n	y	n	n	n
3	b	*Does the survey target locations within specified regions;*	*Major currents, coastal features*	y/n	y	y	n	n	n	n	y	y	n	y	n	n	n
3	c	*Does the survey target locations within specified regions;*	*Proximity to sources*	y/n	y	n	n	n	y	n	y	n	n	y	n	n	n
3	d	*Does the survey target locations within specified regions;*	*Anthropogenic (borders)*	y/n	n	n	y	y	y	y	y	n	n	y	n	n	n
4	a	*Does the survey collect data on sea conditions at the time of the survey?*	*Wave height and frequency*	y/n	n	n	n	n	n	n	n	y	n	n	n	n	n
4	b	*Does the survey collect data on sea conditions at the time of the survey?*	*Wind strength and direction*	y/n	y	y	n	n	y	n	n	y	n	n	n	n	n
4	c	*Does the survey collect data on sea conditions at the time of the survey?*	*Visibility*	y/n	n	n	n	n	n	n	n	n	n	y	n	n	n
5		*Can the survey be achieved without specialised equipment?*		y/n	n	n	n	y	n	y	y	y	n	n	n	y	n
		Sampling units and frequency															
6	a	*Are discrete sampling units employed?*	*What size/length (metres)*	Val	1000	500	10x10 / 1000x 1000	n	500	n	100 & 1000 m	1000 - 1500	1000	n	n	10	n
6	b	*Are discrete sampling units employed?*	*Level of replication (per survey/beach)*	Val	3	20s	1-3	n	n	n	n	3	3	n	n	5	n
6	c	*Are discrete sampling units employed?*	*Separation between sampling units (i.e. spatial independence -metres)*	Val	500	50	200	n	n	n	n	n	n	n	n	n	n
6	d	*Are discrete sampling units employed?*	*Fixed*	y/n	y	y	y	y	y	y	y	n	y	n	n	y	n

Number	Part	Key issue	Detail	Variable	AMDS	NMDMP	NOWPAP – Benthic	NOWPAP – Beach	Korea	ICC	OSPAR – Beach	CCALMR	WWF	Japan	FAP	CCI (Israel)	Hawaii
7		*What is the sampling frequency (in months)?*		Val	3	1	12	12	1	12	4	12 monthly sum	12	0	12	0.5	12
8		*Does the sampling frequency align with specific events?*		y/n	n	n	y	y	n	n	n	n	n	n	n	n	n
9		*Is there capacity for ad-hoc litter reporting?*		y/n	y	n	n	n	n	n	n	n	n	n	n	n	n
		Litter characterization															
10	a	*Are there size limits (area, volume or weight) on the litter considered?*	*Minimum size*	y/n	y	y	n	n	y	n	n	y	y	y	n	y	n
10	b	*Are there size limits (area, volume or weight) on the litter considered?*	*Maximum size*	y/n	n	n	n	n	n	n	n	n	n	n	n	n	n
11		*What is the maximum number of categories for litter classification?*		Val	92	31	41	96	30	45	107	56	41	6	n	1	250
12	a	*Does the survey allow for higher level summaries across litter categories?*	*Composition*	y/n	y	y	y	y	y	y	y	y	y	n	n	n	y
12	b	*Does the survey allow for higher level summaries across litter categories?*	*Form*	y/n	y	n	n	n	y	n	n	y	y	n	n	n	y
12	c	*Does the survey allow for higher level summaries across litter categories?*	*Size*	y/n	n	n	n	n	n	n	y	y	y	n	n	n	y
12	d	*Does the survey allow for higher level summaries across litter categories?*	*Indicator groups*	y/n	n	y	n	y	y	y	y	n	n	y	n	n	y
13	a	*What measures are used to quantify litter (generally on a unit area basis)?*	*Presence/absence*	y/n	y	y	y	y	y	y	y	y	y	y	n	n	y
13	b	*What measures are used to quantify litter (generally on a unit area basis)?*	*Counts within each litter category*	y/n	y	y	y	y	y	y	y	y	y	y	y	y	y
13	c	*What measures are used to quantify litter (generally on a unit area basis)?*	*Weight/volume within each litter category*	y/n	y	n	y	n	n	n	n	y	y	n	y	n	n
13	d	*What measures are used to quantify litter (generally on a unit area basis)?*	*Counts or weights within size classes*	y/n	n	n	n	n	n	n	y	y	n	n	n	n	y
13	e	*What measures are used to quantify litter (generally on a unit area basis)?*	*Catch per unit effort (for trawl surveys)*	y/n	n	n	n	n	n	n	n	n	n	n	n	n	n
14		*Is there a mechanism for identification of sources for litter components?*		y/n	y	n	n	n	n	y	y	y	y	n	n	n	n
15		*Are there are any identification/classification tools/criteria available?*		y/n	n	n	n	n	n	n	y	y	y	n	n	n	y
16	a	*Are data collected on entrapped fauna?*	*Species*	y/n	y	y	n	y	y	y	n	n	y	n	n	n	y
16	b	*Are data collected on entrapped fauna?*	*Entrapment type (includes ingestion)*	y/n	y	n	n	y	n	y	n	n	y	n	n	n	y
16	c	*Are data collected on entrapped fauna?*	*Health status*	y/n	y	y	n	y	y	y	n	n	y	n	n	n	y

Number	Part	Key issue	Detail	Variable	AMDS	NMDMP	NOWPAP – Benthic	NOWPAP – Beach	Korea	ICC	OSPAR – Beach	CCALMR	WWF	Japan	FAP	CCI (Israel)	Hawaii
17		*Is there a mechanism to deal with objects that cannot be removed?*		y/n	y	n	y	n	y	y	n	y	n	n	n	n	n
18		*Are large natural litter items considered?*		y/n	n	n	n	n	n	n	n	n	n	y	n	n	n
19		*Does the survey standardize/normalize survey effort within sampling units?*		y/n	y	y	n	y	y	y	y	y	y	y	n	y	n
		Logistics and facilitation															
20		*Does the survey use the same field staff in each survey?*		y/n	y	y	y	n	n	n	y	y	y	y	n	y	y
21		*Is there a training program for field staff?*		y/n	n	y	n	n	n	n	n	y	n	n	n	n	n
22		*Is there a guidebook/manual for the survey?*		y/n	y	y	y	y	y	y	y	n	y	n	n	n	n
23		*Is there a mechanism to ensure QA/QC on the data?*		y/n	n	y	n	n	n	n	y	n	n	n	n	n	n
24		*Does the survey rely on logistic and technical support and/or advice from external partners?*		y/n	y	y	y	y	y	y	y	n	y	n	y	y	y
25		*Is there a centralised data storage, manipulation and archiving facility?*		y/n	n	y	y	y	y	y	y	y	y	y	y	y	n
26		*Is there online assistance and/or data entry and summary interface?*		y/n	n	n	y	y	n	y	y	n	n	n	n	n	n
27		*Is data recording done during the process of litter collection (rather than at the end of the sampling unit)?*		y/n	n	n	n	n	n	n	n	y	n	y	n	y	n
28		*How many datasheets does the survey require?*		Val	10	1	1	3	1	1	2	2	4	1	n	1	n
		Beach surveys															
29		*Does the survey protocol target specific types of beach according to a range of selection criteria?*		y/n	y	y		y	y	n	y	y	n			n	
30	a	*Does the survey collect data on the depositional nature of each beach;*	*Local and offshore currents*	y/n	y	n		n	y	n	y	n	n			n	
30	b	*Does the survey collect data on the depositional nature of each beach;*	*Beach slope*	y/n	y	y		n	n	n	y	y	n			n	
30	c	*Does the survey collect data on the depositional nature of each beach;*	*Beach aspect*	y/n	y	y		n	n	n	y	n	n			n	
30	d	*Does the survey collect data on the depositional nature of each beach;*	*Beach length*	y/n	y	n		n	n	n	n	y	n			n	
30	e	*Does the survey collect data on the depositional nature of each beach;*	*Tidal range*	y/n	y	n		n	n	n	n	n	n			n	
30	f	*Does the survey collect data on the depositional nature of each beach;*	*Prevailing wind*	y/n	y	y		n	y	n	n	n	n			n	

Number	Part	Key issue	Detail	Variable	AMDS	NMDMP	NOWPAP – Benthic	NOWPAP – Beach	Korea	ICC	OSPAR – Beach	CCALMR	WWF	Japan	FAP	CCI (Israel)	Hawaii
30	g	*Does the survey collect data on the depositional nature of each beach;*	*Nature of the back of the beach (dunes, vegetation, cliff or built structures)*	y/n	y	n		n	n	n	n	n	n			n	
30	h	*Does the survey collect data on the depositional nature of each beach;*	*Storm frequency*	y/n	n	y		n	n	n	n	n	n			n	
30	i	*Does the survey collect data on the depositional nature of each beach;*	*Substrate*	y/n	n	n		n	n	n	n	y	n			n	
31	a	*Does the survey collect data on each beach at the time of the survey;*	*Current winds*	y/n	y	y		n	y	n	n	n	n			n	
31	b	*Does the survey collect data on each beach at the time of the survey;*	*Current tide*	y/n	y	n		n	y	n	n	n	n			n	
31	c	*Does the survey collect data on each beach at the time of the survey;*	*Weather conditions in preceding period*	y/n	y	y		n	n	n	n	n	n			n	
31	d	*Does the survey collect data on each beach at the time of the survey;*	*Levels of beach wrack (natural seagrass and or seaweed)*	y/n	y	n		n	n	n	n	n	n			n	
32	a	*Does the survey collect data on anthropogenic factors;*	*Access (pedestrian, vehicular, boat)*	y/n	y	y		n	n	n	y	n	n			n	
32	b	*Does the survey collect data on anthropogenic factors;*	*Location (metropolitan, peri-urban, rural or remote)*	y/n	y	n		n	n	n	y	y	n			n	
32	c	*Does the survey collect data on anthropogenic factors;*	*Beach usage (bathing, fishing, isolated)*	y/n	y	n		n	n	n	y	n	n			n	
32	d	*Does the survey collect data on anthropogenic factors;*	*Level of use (light, moderate, heavy)*	y/n	y	n		n	n	n	y	n	n			n	
32	e	*Does the survey collect data on anthropogenic factors;*	*Proximity to major rivers or other potential sources*	y/n	y	n		n	n	n	y	n	n			n	
32	f	*Does the survey collect data on anthropogenic factors;*	*Litter collection and disposal facilities*	y/n	n	n		n	n	n	y	n	n			n	
33	a	*How is the landward edge of the beach survey defined?*	*Dunes*	y/n	y	y		n	n	n	n	n	y			y	
33	b	*How is the landward edge of the beach survey defined?*	*Vegetation*	y/n	y	y		n	n	n	n	n	n			y	
33	c	*How is the landward edge of the beach survey defined?*	*Cliff*	y/n	y	y		n	n	n	n	n	n			y	
33	d	*How is the landward edge of the beach survey defined?*	*High tide*	y/n	y	n		n	n	n	n	n	n			n	
33	e	*How is the landward edge of the beach survey defined?*	*Anthropogenic*	y/n	n	n		n	y	n	n	n	n			y	
34	a	*How is the seaward edge of the beach survey defined?*	*Tide marks*	y/n	y	n		n	n	n	n	y	n			n	
34	b	*How is the seaward edge of the beach survey defined?*	*Current water level*	y/n	n	y		n	n	n	n	y	y			y	
34	c	*How is the seaward edge of the beach survey defined?*	*Fixed distance*	y/n	n	n		y	y	n	n	n	n			n	

Number	Part	Key issue	Detail	Variable	AMDS	NMDMP	NOWPAP – Benthic	NOWPAP – Beach	Korea	ICC	OSPAR – Beach	CCALMR	WWF	Japan	FAP	CCI (Israel)	Hawaii
		Benthic surveys															
35	a	*Does the survey comprise;*	*SCUBA observation or clearance*	y/n			y										y
35	b	*Does the survey comprise;*	*Submersible/camera tow observations*	y/n			n										n
35	c	*Does the survey comprise;*	*Benthic trawl*	y/n			y										n
36		*Is litter collected (SCUBA and trawl surveys)?*		y/n			y										y
37		*Does the survey target specific areas and/or particular substrates, depths or currents?*		y/n			y										y
38	a	*Does the survey collect data on the nature of the seabed;*	*Substrate*	y/n			n										y
38	b	*Does the survey collect data on the nature of the seabed;*	*Depth*	y/n			n										y
38	c	*Does the survey collect data on the nature of the seabed;*	*Topography*	y/n			n										n
38	d	*Does the survey collect data on the nature of the seabed;*	*Bottom currents*	y/n			n										n
38	e	*Does the survey collect data on the nature of the seabed;*	*Sedimentology*	y/n			n										n
39	a	*For trawl surveys is data collected on;*	*Vessel characteristics*	y/n			y										n
39	b	*For trawl surveys is data collected on;*	*Grapple or net mesh characteristics*	y/n			y										n
39	c	*For trawl surveys is data collected on;*	*If different nets/grapples are used between observations*	y/n			y										n
40		*For camera tow/submersible observations is data collected on the angle of the field of view through the lens/observation port?*		y/n			?										n
41	a	*For SCUBA, camera tow/submersible observations is data collected on;*	*Visibility at the time of the survey*	y/n			n										y
41	b	*For SCUBA, camera tow/submersible observations is data collected on;*	*Is there a maximum viewing distance*	y/n			n										n
		Floating litter															
42	a	*Does the survey of floating litter occur as;*	*Observations from a vessel*	y/n										y	y		
42	b	*Does the survey of floating litter occur as;*	*Observations from aircraft*	y/n										n	y		

Number	Part	Key issue	Detail	Variable	AMDS	NMDMP	NOWPAP – Benthic	NOWPAP – Beach	Korea	ICC	OSPAR – Beach	CCALMR	WWF	Japan	FAP	CCI (Israel)	Hawaii
42	c	*Does the survey of floating litter occur as;*	*A trawl operation*	y/n										n	y		
43		*Is the same survey site considered in repeated surveys targeted at specific currents or locations?*		y/n										n	y		
44	a	*For vessel and aerial observations, is there data collected or specified criteria for;*	*Height above water level*	y/n										y	n		
44	b	*For vessel and aerial observations, is there data collected or specified criteria for;*	*Position on the vessel/aircraft*	y/n										y	n		
44	c	*For vessel and aerial observations, is there data collected or specified criteria for;*	*Field of view (angle)*	y/n										n	n		
44	d	*For vessel and aerial observations, is there data collected or specified criteria for;*	*Visibility at the time of the survey*	y/n										y	n		
44	e	*For vessel and aerial observations, is there data collected or specified criteria for;*	*Estimating distances to litter*	y/n										y	n		
44	f	*For vessel and aerial observations, is there data collected or specified criteria for;*	*A maximum viewing distance*	y/n										y	n		
44	g	*For vessel and aerial observations, is there data collected or specified criteria for;*	*Speed, direction, position and time period for each sample*	y/n										y	n		
45		*Can the survey be achieved in conjunction with other observations?*		y/n										n	y		
46	a	*For trawl surveys is data collected on;*	*Vessel characteristics*	y/n										n	n		
47	b	*For trawl surveys is data collected on;*	*Speed, direction, position and time period for each sample*	y/n										n	n		
46	c	*For trawl surveys is data collected on;*	*Net mesh and size characteristics*	y/n										n	n		
46	d	*For trawl surveys is data collected on;*	*If different nets are used between observations*	y/n										n	n		
46	e	*For trawl surveys is data collected on;*	*Depth (reach below surface) of the trawl*	y/n										n	n		

Appendix C. Marine litter characterization

Litter characterizations are presented in three different formats:

- A list of the litter types required for beach surveys (both rapid and comprehensive) – Table 10.
- A subset of the litter types to be used in surveys where litter are not collected (floating and benthic remote observations) – Table 11.
- A comparison table relating the beach survey list to other marine litter characterizations, including those employed in the OSPAR, AMDS, WWF, NMDMP, ICC, CCAMLR, NOWPAP – Benthic and NOWPAP – Beach surveys – Table 12.

Table 10. List of litter types for comprehensive and rapid beach surveys. In all cases quantification can be made using either counts, weights and volumes.

Number	Material	Code	Litter type
1	Plastic	PL01	Bottle caps & lids
2	Plastic	PL02	Bottles < 2 L
3	Plastic	PL03	Bottles, drums, jerrycans & buckets > 2 L
4	Plastic	PL04	Knives, forks, spoons, straws, stirrers, (cutlery)
5	Plastic	PL05	Drink package rings, six-pack rings, ring carriers
6	Plastic	PL06	Food containers (fast food, cups, lunch boxes & similar)
7	Plastic	PL07	Plastic bags (opaque & clear)
8	Plastic	PL08	Toys & party poppers
9	Plastic	PL09	Gloves
10	Plastic	PL10	Cigarette lighters
11	Plastic	PL11	Cigarettes, butts & filters
12	Plastic	PL12	Syringes
13	Plastic	PL13	Baskets, crates & trays
14	Plastic	PL14	Plastic buoys
15	Plastic	PL15	Mesh bags (vegetable, oyster nets & mussel bags)
16	Plastic	PL16	Sheeting (tarpaulin or other woven plastic bags, palette wrap)
17	Plastic	PL17	Fishing gear (lures, traps & pots)
18	Plastic	PL18	Monofilament line
19	Plastic	PL19	Rope
20	Plastic	PL20	Fishing net
21	Plastic	PL21	Strapping
22	Plastic	PL22	Fibreglass fragments
23	Plastic	PL23	Resin pellets
24	Plastic	PL24	Other (specify)
25	Foamed Plastic	FP01	Foam sponge
26	Foamed Plastic	FP02	Cups & food packs
27	Foamed Plastic	FP03	Foam buoys
28	Foamed Plastic	FP04	Foam (insulation & packaging)
29	Foamed Plastic	FP05	Other (specify)
30	Cloth	CL01	Clothing, shoes, hats & towels
31	Cloth	CL02	Backpacks & bags
32	Cloth	CL03	Canvas, sailcloth & sacking (hessian)
33	Cloth	CL04	Rope & string
34	Cloth	CL05	Carpet & furnishing
35	Cloth	CL06	Other cloth (including rags)
36	Glass & ceramic	GC01	Construction material (brick, cement, pipes)

Number	Material	Code	Litter type
37	Glass & ceramic	GC02	Bottles & jars
38	Glass & ceramic	GC03	Tableware (plates & cups)
39	Glass & ceramic	GC04	Light globes/bulbs
40	Glass & ceramic	GC05	Fluorescent light tubes
41	Glass & ceramic	GC06	Glass buoys
42	Glass & ceramic	GC07	Glass or ceramic fragments
43	Glass & ceramic	GC08	Other (specify)
44	Metal	ME01	Tableware (plates, cups & cutlery)
45	Metal	ME02	Bottle caps, lids & pull tabs
46	Metal	ME03	Aluminium drink cans
47	Metal	ME04	Other cans (< 4 L)
48	Metal	ME05	Gas bottles, drums & buckets (> 4 L)
49	Metal	ME06	Foil wrappers
50	Metal	ME07	Fishing related (sinkers, lures, hooks, traps & pots)
51	Metal	ME08	Fragments
52	Metal	ME09	Wire, wire mesh & barbed wire
53	Metal	ME10	Other (specify), including appliances
54	Paper & cardboard	PC01	Paper (including newspapers & magazines)
55	Paper & cardboard	PC02	Cardboard boxes & fragments
56	Paper & cardboard	PC03	Cups, food trays, food wrappers, cigarette packs, drink containers
57	Paper & cardboard	PC04	Tubes for fireworks
58	Paper & cardboard	PC05	Other (specify)
59	Rubber	RB01	Balloons, balls & toys
60	Rubber	RB02	Footwear (flip-flops)
61	Rubber	RB03	Gloves
62	Rubber	RB04	Tyres
63	Rubber	RB05	Inner-tubes and rubber sheet
64	Rubber	RB06	Rubber bands
65	Rubber	RB07	Condoms
66	Rubber	RB08	Other (specify)
67	Wood	WD01	Corks
68	Wood	WD02	Fishing traps and pots
69	Wood	WD03	Ice-cream sticks, chip forks, chopsticks & toothpicks
70	Wood	WD04	Processed timber and pallet crates
71	Wood	WD05	Matches & fireworks
72	Wood	WD06	Other (specify)
73	Other	OT01	Paraffin or wax
74	Other	OT02	Sanitary (nappies, cotton buds, tampon applicators, toothbrushes)
75	Other	OT03	Appliances & Electronics
76	Other	OT04	Batteries (torch type)
77	Other	OT05	Other (specify)

Table 11. List of litter types for remote observations (benthic and floating).

General litter class	Code	Litter description with examples
Containers	RL01	Bottle caps, lids & pull tabs
	RL02	Bottles < 2 L
	RL03	Bottles, drums & buckets > 2 L
Fishing & Boating	RL04	Buoys
	RL05	Fishing net
	RL06	Fishing related (sinkers, lures, hooks, traps, pots & baskets/trays)
	RL07	Monofilament line
	RL08	Rope
Food & Beverage	RL09	Cups, food trays, fast food wrappers & cardboard drink containers
	RL10	Drink cans
	RL11	Drink package rings
	RL12	Ice-cream sticks, chip forks, chopsticks, toothpicks, matches & fireworks
Packaging	RL13	Foam (insulation & packaging)
	RL14	Paper & cardboard
	RL15	Plastic bags (opaque & clear)
	RL16	Plastic sheet or plastic tarpaulin
	RL17	Strapping
Sanitary	RL18	Sanitary (nappies, tampon applicators, cotton buds, condoms, etc)
Smoking	RL19	Cigarette butts
	RL20	Cigarette lighters
Other	RL21	Fluorescent light tubes
	RL22	Light globes
	RL23	Other (specify)
	RL24	Processed timber
	RL25	Rags, clothing, shoes, hats & towels
	RL26	Tableware
	RL27	Toys
	RL28	Tyres & Inner-tubes
	RL29	Wire, wire mesh & barbed wire

Table 12. Comparison of the litter characterization categories used in selected surveys showing the alignment with the unified litter classes recommended for the beach litter sampling guidelines.

Unified code	Unified litter type	OSPAR	AMDS	WWF	NMDMP	ICC	CCAMLR	NOWPAP – Benthic	NOWPAP – Beach (NPEC data card)
CL01	Clothing, shoes, hats & towels	Clothing	Clothing			Clothing Shoes		Clothes	Clothes
CL01	Clothing, shoes, hats & towels	Shoes					Shoes		
CL01	Clothing, shoes, hats & towels		Hats						
CL01	Clothing, shoes, hats & towels						Gloves		Cotton work gloves
CL02	Backpacks & bags		Bags						
CL02	Backpacks & bags							Blanket/ Carpet	
CL03	Canvas, sailcloth & sacking (hessian)	Sacking							
CL03	Canvas, sailcloth & sacking (hessian)		Canvas						
CL03	Canvas, sailcloth & sacking (hessian)		Sailcloth						
CL03	Canvas, sailcloth & sacking (hessian)							Leather	
CL04	Rope & string	Rope/strings					Ropes open		String
CL04	Rope & string						Ropes loops		
CL04	Rope & string								Thread, yarn
CL05	Carpet & furnishing	Furnishing							
CL06	Other cloth (including rags)	Other textiles (specify)	Other	Other			Other fabric (specify)	Others	Others (specify)
CL06	Other cloth (including rags)		Rags	Cloth & fabric			Cloths		
CL06	Other cloth (including rags)						Fabric Pieces		Pieces of cloth
CL06	Other cloth (including rags)							Awning	
FP01	Foam sponge	Foam sponge							
FP02	Cups & food packs		Cups or food trays	Cups, plates, trays					Cups
FP02	Cups & food packs								Food trays
FP02	Cups & food packs								Lunch box for noodle
FP03	Foam buoys		Foam buoys					Buoys	Buoys
FP04	Foam (insulation & packaging)		Insulation foam	Insulation					

Unified code	Unified litter type	OSPAR	AMDS	WWF	NMDMP	ICC	CCAMLR	NOWPAP – Benthic	NOWPAP – Beach (NPEC data card)
FP04	Foam (insulation & packaging)		Packaging foam	Packaging			Styrofoam packaging	Container	Packing materials
FP04	Foam (insulation & packaging)	Plastic/polystyrene pieces < 50 cm	Other	Fragments of plastic					Plastic
FP04	Foam (insulation & packaging)	Plastic/polystyrene pieces > 50 cm							
FP04	Foam (insulation & packaging)	Other plastic/polystyrene items (specify)	Other	Other			Other plastics (specify)		
FP05	Other (specify)		Other					Others	Other (specify)
FP05	Other (specify)								Broken pieces
GC01	Construction material (brick, cement, pipes)	Construction material				Building materials			Tiles, bricks
GC01	Construction material (brick, cement, pipes)		Construction materials						
GC02	Bottles & jars	Bottles	Bottles or jars	Bottles & jars		Beverage bottles (glass)	Beverage bottles	Bottles	Drinking containers
GC02	Bottles & jars							Glass products	
GC02	Bottles & jars								Cosmetic containers
GC02	Bottles & jars						Food jars		Food containers
GC03	Tableware (plates & cups)							Tableware	Tableware
GC04	Light globes/bulbs	Light bulbs/ tubes	Light globes	Light bulbs	Light bulbs, tubes	Light bulbs/ tubes	Light bulbs/ tubes		Bulbs
GC05	Fluorescent light tubes		Fluorescent light tubes						Fluorescents
GC06	Glass buoys		Glass buoys						
GC07	Glass or ceramic fragments								Pieces of ceramic
GC07	Glass or ceramic fragments						Pieces		
GC07	Glass or ceramic fragments								Pieces of glass

Unified code	Unified litter type	OSPAR	AMDS	WWF	NMDMP	ICC	CCAMLR	NOWPAP – Benthic	NOWPAP – Beach (NPEC data card)
GC08	Other (specify)	Other ceramic/ pottery items (specify)							
GC08	Other (specify)	Other glass items (specify)	Other	Other			Other glass (specify)	Others	Others (specify)
ME01	Tableware (plates, cups & cutlery)							Plates	
ME02	Bottle caps, lids & pull tabs	Bottle caps	Bottle caps				Bottle caps		Caps
ME02	Bottle caps, lids & pull tabs					Pull tabs			Pull tab
ME03	Aluminium drink cans	Drink cans	Aluminium cans	Aluminium cans	Metal beverage cans	Beverage cans	Cans/ beverage		Aluminium drinking cans
ME04	Other cans (< 4 L)	Aerosol/ Spray cans	Aerosol cans	Aerosol cans			Cans/ aerosol		Spray bottles
ME04	Other cans (< 4 L)	Food cans	Tin cans	Tin cans			Cans/ food	Cans	Food cans
ME04	Other cans (< 4 L)	Paint tins							
ME04	Other cans (< 4 L)						Cans/ other		Cans other
ME04	Other cans (< 4 L)								Steel drinking cans
ME05	Gas bottles, drums & buckets (> 4 L)	Oil drums (new not rusty)	Metal drums (>2L)	Drums		55 gallon drums	Drums		
ME05	Gas bottles, drums & buckets (> 4 L)	Oil drums (old/rusty)							
ME05	Gas bottles, drums & buckets (> 4 L)		Buckets						
ME05	Gas bottles, drums & buckets (> 4 L)		Gas cylinders		Oil/ gas containers				
ME06	Foil wrappers	Foil wrappers							Aluminium foil
ME07	Fishing related (sinkers, lures, hooks, traps & pots)	Fishing weights						Fishing gear	Sinkers
ME07	Fishing related (sinkers, lures, hooks, traps & pots)	Lobster/crab pots	Fishing traps & pots						
ME07	Fishing related (sinkers, lures, hooks, traps & pots)								Fishing hooks
ME07	Fishing related (sinkers, lures, hooks, traps & pots)								Fishing other
ME08	Fragments	Industrial scrap					Pieces		

Unified code	Unified litter type	OSPAR	AMDS	WWF	NMDMP	ICC	CCAMLR	NOWPAP – Benthic	NOWPAP – Beach (NPEC data card)
ME08	Fragments	Other metal pieces < 50 cm (specify)	Other	Other			Other metal (specify)	Others	Pieces of metal
ME08	Fragments	Other metal pieces > 50 cm (specify)							
ME08	Fragments								Nails
ME09	Wire, wire mesh & barbed wire	Wire, wire mesh, barbed wire					Wire	Wire/Rope	Wire
ME10	Other (specify)	Electric appliances				Appliances (refrigerators, washers, etc)			
ME10	Other (specify)								Others (specify)
OT01	Paraffin or wax	Paraffin or wax 0–1 cm							
OT01	Paraffin or wax	Paraffin or wax 1–10 cm							
OT01	Paraffin or wax	Paraffin or wax > 10 cm							
OT02	Sanitary (nappies, cotton buds, tampon applicators, toothbrushes)	Combs/hair brushes	Toothbrushes & hair brushes	Toothbrushes & hair brushes					
OT02	Sanitary (nappies, cotton buds, tampon applicators, toothbrushes)		Tampon applicators						
OT02	Sanitary (nappies, cotton buds, tampon applicators, toothbrushes)	Cotton bud sticks			Cotton swabs				
OT02	Sanitary (nappies, cotton buds, tampon applicators, toothbrushes)	Other medical items (swabs, bandaging etc.)							
OT02	Sanitary (nappies, cotton buds, tampon applicators, toothbrushes)	Other sanitary items (specify)							
OT02	Sanitary (nappies, cotton buds, tampon applicators, toothbrushes)	Sanitary towels/panty liners/backing strips	Sanitary ware						

Unified code	Unified litter type	OSPAR	AMDS	WWF	NMDMP	ICC	CCAMLR	NOWPAP – Benthic	NOWPAP – Beach (NPEC data card)
OT02	Sanitary (nappies, cotton buds, tampon applicators, toothbrushes)	Tampons & tampon applicators			Tampon applicators	Tampons/Tampon applicators			
OT02	Sanitary (nappies, cotton buds, tampon applicators, toothbrushes)	Toilet fresheners							
OT02	Sanitary (nappies, cotton buds, tampon applicators, toothbrushes)		Disposable nappies	Disposable nappies		Diapers			
OT03	Appliances & Electronics		Appliances						
OT03	Appliances & Electronics							Electronics	
OT04	Batteries (torch type)		Batteries (torch type)						
OT05	Other (specify)		Car batteries (wet cell)			Batteries			
OT05	Other (specify)		Other					Others	Other (specify)
OT05	Other (specify)								Bulk waste (specify)
OT05	Other (specify)								Oil ball
PC01	Paper (including newspapers & magazines)	Newspapers & magazines					Newspapers/Magazines	Book/Newspaper	Newspaper/magazine/leaflet
PC01	Paper (including newspapers & magazines)								Tissue
PC02	Cardboard boxes & fragments	Bags	Paper	Paper & Cardboard			Bags	Container	Bags
PC02	Cardboard boxes & fragments	Cardboard					Cardboard	Packages	Cardboard box
PC02	Cardboard boxes & fragments		Boxes & cartons	Cardboard cartons					
PC02	Cardboard boxes & fragments								Heavy paper box
PC02	Cardboard boxes & fragments								Broken pieces
PC03	Cups, food trays, food wrappers, cigarette packs, drink containers	Cartons/Tetraps aks	Grease proof cardboard drink containers				Cartons		Drinking packages
PC03	Cups, food trays, food wrappers, cigarette packs, drink containers	Cigarette packets				Tobacco Packaging/Wrappers			

Unified code	Unified litter type	OSPAR	AMDS	WWF	NMDMP	ICC	CCAMLR	NOWPAP – Benthic	NOWPAP – Beach (NPEC data card)
PC03	Cups, food trays, food wrappers, cigarette packs, drink containers	Cups	Cups or food trays				Cups		Cups
PC03	Cups, food trays, food wrappers, cigarette packs, drink containers								Plates
PC03	Cups, food trays, food wrappers, cigarette packs, drink containers								Snack package
PC04	Tubes for fireworks								Tubes for fireworks
PC05	Other (specify)	Other paper items (specify)	Other				Other paper (specify)	Others	Others
PL01	Bottle caps & lids	Caps/lids	Bottle caps	Bottle caps			Caps/lids		Caps, lids
PL02	Bottles < 2 L	Cleaner			Cleaner	Bleach/ Cleaner bottles		Containers	Detergent or bleach
PL02	Bottles < 2 L	Cosmetics (e.g. sun lotion, shampoo, shower gel, deodorant)	Opaque plastic bottles (< 2L)	Plastic bottles – coloured					
PL02	Bottles < 2 L	Drinks	Clear plastic bottles (<2L)	Plastic bottles – clear	Beverage bottles	Beverage bottles (plastic) 2 L or less	Bottles	Bottles	Drinking
PL02	Bottles < 2 L								Seasonings & Sauces
PL03	Bottles, drums, jerrycans & buckets > 2 L	Buckets	Buckets	Buckets, baskets, crates					
PL03	Bottles, drums, jerrycans & buckets > 2 L	Engine oil <50 cm	Plastic oil bottles	Plastic oil bottles	Motor oil containers	Oil/Lube bottles			
PL03	Bottles, drums, jerrycans & buckets > 2 L	Engine oil > 50 cm	Plastic drums (>2 L)						
PL03	Bottles, drums, jerrycans & buckets > 2 L	Jerry cans (square plastic containers with handle)							
PL03	Bottles, drums, jerrycans & buckets > 2 L	Other Bottles/containers/drums			Other plastic bottles				Others

Unified code	Unified litter type	OSPAR	AMDS	WWF	NMDMP	ICC	CCAMLR	NOWPAP – Benthic	NOWPAP – Beach (NPEC data card)
PL04	Knives, forks, spoons, straws, stirrers, (cutlery)	Cutlery/trays/straws				Cups, plates, forks, knives, spoons			Food tray
PL04	Knives, forks, spoons, straws, stirrers, (cutlery)		Drinking straws		Straws				Drinking straw
PL04	Knives, forks, spoons, straws, stirrers, (cutlery)					Straws Stirrers			
PL05	Drink package rings, six-pack rings, ring carriers	4/6-pack yokes	Six pack rings	Six pack rings	Six pack rings	6-pack holders	Six-pack yokes		
PL06	Food containers (fast food, cups, lunch boxes & similar)	Cups							
PL06	Food containers (fast food, cups, lunch boxes & similar)	Food incl. fast food containers			Food				Food, dish
PL06	Food containers (fast food, cups, lunch boxes & similar)	Crisp/sweet packets & lolly sticks	Food wrappers	Food wrappers		Food wrappers/Containers			Snack
PL07	Plastic bags (opaque & clear)	Bags (shopping)	Plastic bags	Plastic bags	Plastic bags with seam < 1 m	Bags	Bags	Bags	Shopping
PL07	Plastic bags (opaque & clear)	Small plastic bags, e.g., freezer bags							Food or package
PL07	Plastic bags (opaque & clear)					Bait containers/packaging			
PL08	Toys & party poppers	Toys & party poppers				Toys			Toy
PL09	Gloves	Gloves							
PL10	Cigarette lighters	Cigarette lighters	Cigarette lighters	Cigarette lighters		Cigarette lighters			Lighter
PL11	Cigarettes, butts & filters	Cigarette butts				Cigarettes/Cigarette filters			Cigarettes
PL11	Cigarettes, butts & filters					Cigar tips			
PL11	Cigarettes, butts & filters								Cigarette filter
PL12	Syringes		Syringes				Other gear (specify)		
PL12	Syringes	Syringes	Syringes	Syringes	Syringes	Syringes			

Unified code	Unified litter type	OSPAR	AMDS	WWF	NMDMP	ICC	CCAMLR	NOWPAP – Benthic	NOWPAP – Beach (NPEC data card)
PL13	Baskets, crates & trays	Crates				Crates	Beverage crates		
PL13	Baskets, crates & trays	Fish boxes							
PL13	Baskets, crates & trays	Oyster trays (round from oyster cultures)	Plastic baskets, plates & trays		Fish baskets				
PL14	Plastic buoys	Floats/Buoys	Plastic buoys	Buoys & floats	Floats/ Buoys	Buoys/ Floats	Trawl Floats		Buoy
PL14	Plastic buoys						Longline floats		
PL15	Mesh bags (vegetable, oyster nets & mussel bags)	Mesh vegetable bags							
PL15	Mesh bags (vegetable, oyster nets & mussel bags)	Oyster nets or mussel bags							
PL15	Mesh bags (vegetable, oyster nets & mussel bags)	Plastic sheeting from mussel culture (Tahitians)							
PL16	Sheeting (tarpaulin or other woven plastic bags, palette wrap)	Fertiliser/animal feed bags							
PL16	Sheeting (tarpaulin or other woven plastic bags, palette wrap)	Industrial packaging, plastic sheeting	Polypropylene tarpaulin/ bags			Plastic Sheeting/			Sheet or bag
PL16	Sheeting (tarpaulin or other woven plastic bags, palette wrap)					Tarps			
PL16	Sheeting (tarpaulin or other woven plastic bags, palette wrap)		Palette wrapper < 1 m squared	Pallet wrappers					
PL16	Sheeting (tarpaulin or other woven plastic bags, palette wrap)		Palette wrapper < 10 m squared						
PL16	Sheeting (tarpaulin or other woven plastic bags, palette wrap)		Palette wrapper < 5 m squared		Plastic sheet >= 1 m				
PL16	Sheeting (tarpaulin or other woven plastic bags, palette wrap)		Palette wrapper >= 10 m squared						

Unified code	Unified litter type	OSPAR	AMDS	WWF	NMDMP	ICC	CCAMLR	NOWPAP – Benthic	NOWPAP – Beach (NPEC data card)
PL16	Sheeting (tarpaulin or other woven plastic bags, palette wrap)				Salt bags				
PL16	Sheeting (tarpaulin or other woven plastic bags, palette wrap)				Plastic bags with seam >= 1 m				
PL17	Fishing gear (lures, traps & pots)	Crab/lobster pots	Fishing traps & pots		Traps/pots	Crab/ Lobster/ Fish traps			
PL17	Fishing gear (lures, traps & pots)	Octopus pots							
PL17	Fishing gear (lures, traps & pots)		Fishing lures	Lures		Fishing lures/ light sticks			Lure, float
PL18	Monofilament line	Fishing line (angling)							Fishing line
PL18	Monofilament line		Monofilament line < 1 m long						
PL18	Monofilament line		Monofilament line < 10 m long						
PL18	Monofilament line		Monofilament line < 5 m long						
PL18	Monofilament line		Monofilament line >= 10 m long	Fishing line	Fishing line	Fishing line			
PL19	Rope	Rope/cord/nets < 50 cm							Rope
PL19	Rope	Rope/cord/nets > 50 cm		Ropes					
PL19	Rope		Rope < 1 m long						
PL19	Rope		Rope < 10 m long						
PL19	Rope		Rope < 5 m long		Rope > 1 m	Rope			
PL19	Rope		Rope >= 10 m long						
PL19	Rope						Ropes open		
PL19	Rope						Ropes loops		

Unified code	Unified litter type	OSPAR	AMDS	WWF	NMDMP	ICC	CCAMLR	NOWPAP – Benthic	NOWPAP – Beach (NPEC data card)
PL19	Rope								String
PL20	Fishing net	Tangled nets/ cord							
PL20	Fishing net		Fishing net < 1 m squared		Nets >= 5 meshes	Fishing nets	Trawl web	Fishing nets	
PL20	Fishing net		Fishing net < 5 m squared						
PL20	Fishing net		Fishing net < 10 m squared						
PL20	Fishing net		Fishing net >= 10 m squared						
PL20	Fishing net						Monofilament gillnet		
PL20	Fishing net						Multifilament gillnet		
PL21	Strapping	Strapping bands	Strapping	Strapping		Strapping bands			Tape
PL21	Strapping				Straps open		Open strapping bands		
PL21	Strapping				Straps closed		Closed strapping bands		
PL22	Fibreglass fragments	Fibre glass							
PL23	Resin pellets	Plastic pellets						Resin pellets	Resin pellets
PL24	Other (specify)	Car parts	Cars & car parts			Car/ Car parts			
PL24	Other (specify)	Hard hats	Hard hats	Hard hats					
PL24	Other (specify)	Injection gun containers							
PL24	Other (specify)	Light sticks (tubes with fluid)			Light sticks				

Unified code	Unified litter type	OSPAR	AMDS	WWF	NMDMP	ICC	CCAMLR	NOWPAP – Benthic	NOWPAP – Beach (NPEC data card)
PL24	Other (specify)	Pens							Stationary
PL24	Other (specify)	Shoes/sandals	Footwear						
PL24	Other (specify)	Shotgun cartridges				Shotgun Shells/Wadding			
PL24	Other (specify)				Pipe thread protectors				
PL24	Other (specify)	Containers/ tubes							
PL24	Other (specify)								Other
RB01	Balloons, balls & toys	Balloons	Balloons		Balloons	Balloons		Balloon	
RB01	Balloons, balls & toys							Balls	Balls
RB02	Footwear (flip-flops)	Boots	Flip-flops or footwear	Thongs & footwear				Boots	Balloon
RB03	Gloves	Gloves	Gloves	Gloves	Gloves		Gloves	Gloves	
RB04	Tyres	Tyres & belts	Tyres			Tires	Tires	Tire	Gloves
RB05	Inner-tubes and rubber sheet		Inner-tubes						
RB06	Rubber bands								Rubber bands
RB07	Condoms	Condoms			Condoms	Condoms			
RB07	Condoms		Condoms						
RB08	Other (specify)	Other rubber pieces (specify)	Other	Other			Other rubber (specify)	Others	Broken pieces
RB08	Other (specify)						Trawl rollers		
RB08	Other (specify)						Pieces		
RB08	Other (specify)								Others (specify)
WD01	Corks	Corks					Corks		
WD02	Fishing traps and pots	Octopus pots							
WD02	Fishing traps and pots	Crab/ lobster pots							
WD03	Ice-cream sticks, chip forks, chopsticks & toothpicks	Ice lolly sticks / chip forks							

Unified code	Unified litter type	OSPAR	AMDS	WWF	NMDMP	ICC	CCAMLR	NOWPAP – Benthic	NOWPAP – Beach (NPEC data card)
WD03	Ice-cream sticks, chip forks, chopsticks & toothpicks							Chopstick	Chopsticks
WD03	Ice-cream sticks, chip forks, chopsticks & toothpicks								Toothpicks
WD04	Processed timber and pallet crates	Crates	Fishing traps & pots				Crates	Box/Basket	
WD04	Processed timber and pallet crates	Pallets	Pallets (or fragments)			Pallets			
WD04	Processed timber and pallet crates		Processed timber < 0.25 m cubed	Wood			Lumber pieces	Timber/logs	Timber/ pieces of wood/square log/board
WD04	Processed timber and pallet crates		Processed timber < 1 m cubed						
WD04	Processed timber and pallet crates		Processed timber >= 1 m cubed						
WD05	Matches & fireworks								Matches
WD05	Matches & fireworks								Fireworks
WD06	Other (specify)	Other wood < 50 cm (specify)	Other	Other			Other (specify)		Other (specify)
WD06	Other (specify)	Other wood > 50 cm (specify)							
WD06	Other (specify)	Paint brushes							
WD06	Other (specify)								Charcoal
	Large items record							Sunken ships	
	Not recorded	Human Faeces							
	Not recorded	Animal Faeces							
	Specify by material type and form		Logo items		Cruiseline logo items				

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